AN ACCOUNT

OF THE

CAVES OF BALLYBUNIAN,

BY

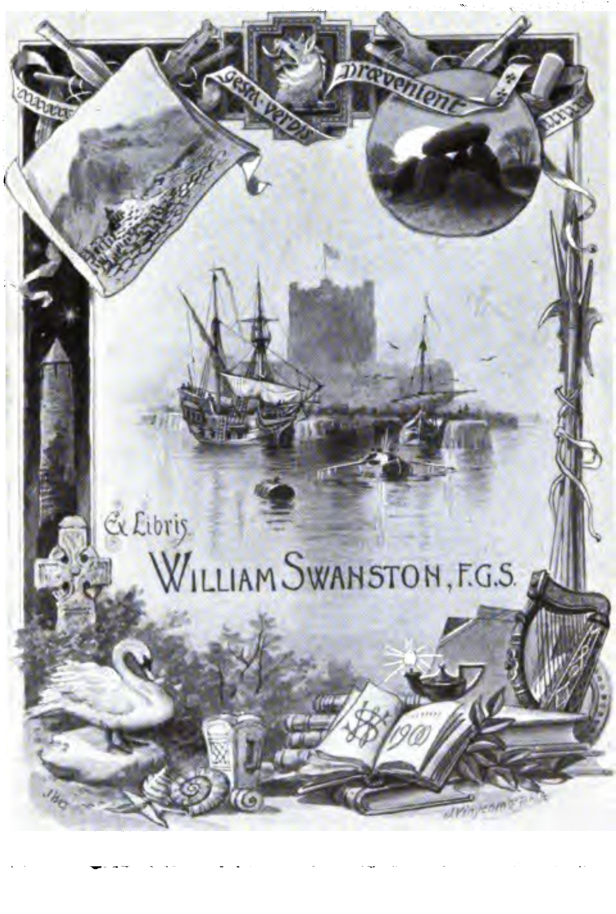
WILLIAM AINSWORTH, ESQ.

Br. from Greer

~~PK56~~

5/-

BL 52



G. A. Kerr 8° 21

Etched by W H Brooke F S A

Dublin Published by W. Curry Jun.r & Co. Nov.r 1828

AN ACCOUNT

OF THE

CAVES OF BALLYBUNIAN,

COUNTY OF KERRY:

WITH SOME

MINERALOGICAL DETAILS.

BY

WILLIAM AINSWORTH, ESQ.

MEMBER OF THE ROYAL GEOGRAPHICAL SOCIETY OF LONDON; CORRESPONDING MEMBER OF THE GEOGRAPHICAL SOCIETY OF PARIS; MEMBER OF THE GEOLOGICAL SOCIETY OF DUBLIN; HONORARY MEMBER OF THE LIMERICK INSTITUTION; MEMBER OF THE ROYAL COLLEGE OF SURGEONS, AND LATE SENIOR PRESIDENT OF THE ROYAL PHYSICAL AND PLINIAN SOCIETIES OF EDINBURGH.

DUBLIN:

WILLIAM CURRY, JUN. AND COMPANY;

SIMPKIN AND MARSHALL, LONDON; BANCKS AND COMPANY, MANCHESTER; AND C. O'BRIEN, LIMERICK.

1834.

G. FOLDS, Printer, 1, St. Andrew-st.
(*Opposite Trinity-st.*)

CONTENTS.

THE

CAVES OF BALLYBUNIAN.

The author of these few pages, has ventured for a moment aside from more important researches on the mineralogy of Ireland, to describe some caves and other local scenery, of which, as of many of the natural beauties and phenomena belonging to this wild and picturesque island, no account has, as yet, been given to the public. He has thought them, on every consideration, worthy of such a notice, and has only to regret that a more able pen was not brought to their delineation.

The description of natural phenomena, which originate in the varied configuration of the earth's surface, is now included among the direct objects of science; such are the form and height of mountains, which have derived so much

importance from the data obtained on the equilibrium of the earth, from their comparison with the depths of the seas and the distribution of plains; the depression of great portions of the earth's surface below the level of the seas in connexion with their climaterial influence; the direction of mountains, the denudation of valleys, the nature and origin of fissures and clefts, and other natural curiosities of the same kind, which, in their investigation, often assist in throwing light upon some of the most striking branches of the natural history of the inorganic world, and apart from the interest and admiration which they excite—admit of their being described much more accurately than could have ever been done without so much enlightened speculation as is not incompatible with the utmost severity of fact.

That part of the coast of Kerry, on which the caves of Ballybunian occur, may be considered as contained between the mouth of the river Feale, called Cashin, where it enters the Shannon to the south, and Kilconly point to the north, comprising nearly the whole length of the barony of Iraghticonnor, and is immediately opposite to the embouchure of the last mentioned great river.*

* The author of the "History of Kerry" has noticed the caves of Ballybunian, in a short paragraph:— "The whole shore here, hath a variety of

For some distance beyond the mouth of the Cashin, the coast is formed of a succession of low sand hills, clothed with luxuriant vegetation; which are succeeded by cliffs of detritus gradually rising to the head land supporting the old castle of Ballybunian; beyond, is the bay attached to the village of the same name, within these few years becoming frequented as a bathing place, and at its northern end, is the commencement of a ridge of cliffs, which extend, with little interruption, to Kilconly point, attaining their maximum elevation above the great caves, and gradually diminishing in height as they approach the promontory of Lick castle, till they finally lose themselves in the sand hills and low lands of Beal. The vegetation of these and the downs of Cashin consists chiefly of sea grasses and sedges (Arundo arenaria, Elymus arenarius and Carex arenaria) whose long creeping rhizomata bind in some

romantic caves and caverns, formed by the dashing of the waves; in some places are high open arches, and in others impending rocks, ready to tumble down upon the first storm." He further says, that this barony is situated between the mouth of the river Shannon and that called the Cashin. It is certain that the hydrographical relations as well as the general features of this great river, give to that part of its embouchure, which extends beyond the opposite points, of Kilconly and Kincradane, the character of a Fiord or Firth (Fleuve of the French); but, since this term is not in use in Ireland we must still consider the Shannon as emptying itself into the sea between the two points of Loop and Kerry head. Under any circumstance, rivers, which in their prolongation would, at a short distance, join a neighbouring great stream, belong to the same hydrographical basin, and thus the Cashin belongs to the basin and watershed of the mouth of the Shannon.

measure the sands, and also of many flowering plants, among which were observed Chlora perfoliata, Samolus Valerandi Cakile-maritima, Scirpus glaucus, Lythospermum maritimum, etc. etc.

The headland on which the remnant of Ballybunian castle stands, in defiance of the strong winds of this coast, is composed of strata of limestone from one to two or three feet in thickness, alternating with thin beds of alum slate very fissile and of an extremely dark colour. The rock is perforated by a subterraneous passage wrought by artificial means, which enters beyond the castle and then divides into two passages, one of which leads to beneath the ruin. All that remains of the castle itself, is a single and lofty wall formerly joined to its counterpart by gable ends and arches of very narrow dimensions.

The bay of Ballybunian is about 500 paces in width, and its sands, which are piled up the sides of its inner portion, are dry and firm, through the prevalence of westerly winds, and the strength of the currents mars the pleasantness and security of the bathing. The cliffs, which front the northern side, extend about 290 yards and rise gradually from the east to the west or towards the sea, where they attain a height of 110 feet. They preserve throughout great perpendicularity, and are composed of two great

beds, from 30 to 40 feet in thickness, of compact ampelite, divided by a seam of the same slate, but fissile and anthracitous, and pouring out streamlets of water which contain iron and salts in solution, and tinge the rocks with bright yellow and ochreous colours. These cliffs are also penetrated by several caves of small dimensions which open upon the bay, and are crossed in one place by a fissure, occasioned by the fracturing of the rock which dips at a small angle of inclination (4° to 5°) to the east. The last cave on the sea side, which has also an entrance from the bay, immediately curves round and allows the sea to be seen breasting its foamy way with much impetuosity, even on calm days, up two distinct apertures through which the light gleams with almost starlight brightness. About thirty paces to the right another passage, at first lofty and easy of access to many persons abreast, but gradually diminishing until blocked up with sand, leads by a first corridor to the right into other caves opening to the sea, this again extending inward to a little circular chamber which joins the inner branch of the vestibule or first passage; secondly, by a low passage which must be crept into, and which, after following a circuitous course, ultimately leads into a vaulted chamber of small dimensions; and thirdly, by a passage which, at the time the author explored these caverns, diminished gradually in height and width till, at about 60 paces from its extremity, it was entirely blocked up by

sand assisted by the water-worn trunk of a tree. It was confidently stated that this passage had been followed across many, if not most, of the caves which penetrate this headland, extending from the north end of Ballybunian bay to that of Dune, a distance of more than 300 yards. The headland, between these two points, throughout its whole extent, presents a nearly horizontal distribution of compact stratified rocks fronting the sea in nearly vertical precipices, and perforated by a great number of channels of different sizes and depths which communicate more or less with one another, and which, from their size being rather less than the loftier and deeper grottos to the north, are called the smaller caves.

Any attempt to describe the connexion and relation of all these minor caves would be obviously a tedious enumeration, not warranted by the importance of the subject: they are most easily navigated in a boat from the northern side, when the rocky passages may be traversed for a considerable distance without any communication with the open sea, and during this navigation, which is chiefly carried on in a line parallel to the western face of the cliff, the various entrances are often crossed at right angles, affording the most striking contrasts of light and shade, the colour of the waters being often of a hue so sparkling bright and so intensely vivid as to resemble molten silver,

while the boat hurrying through the deep and wave-worn arcades into light and airy arches or vaulted chambers, only in their innermost recesses dark and repulsive, and passing from cave to cave, and hall to hall, with inlets pointing to the sea, or high cliffs affording their protection against the waves, and occasionally well-like apertures, which open through the roof to yield a telescopic view of the heavens, assist more especially with the sudden transitions from absolute darkness to the most brilliant light, in giving to the whole an appearance of fairy scenery.

Near the centre of the cliff, the roof of one or more caverns having fallen in, an inlet 170 feet in depth is left, which is beautifully supported at its entrance by two rocky buttresses. These are perforated by the waters and appear latterally like separate archways leading into the same obscure passage, and about 30 feet from this inlet is a large circular opening, also formed by the falling in of the roof of the cave.

To the north, the same cliff forms a headland of about a hundred yards in extent which has sea caves of greater depth and height than those of the southern cliff, with the exception of the one mentioned as occurring at the extreme point, and which is said to join the innermost of these. The three most inland apertures terminate in

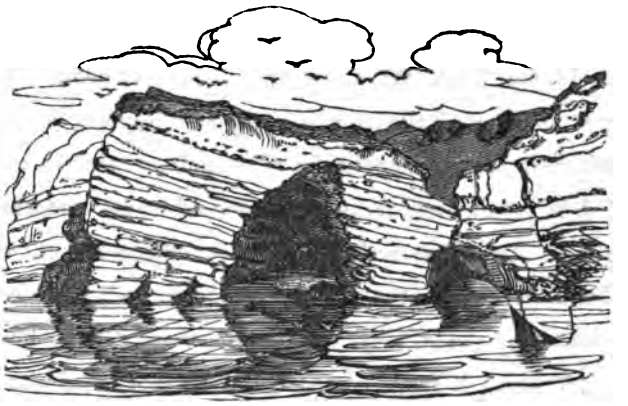
one great passage, which opens into Dune bay by two different arches, and this passage may be almost walked through at extreme low water. In these caves a cleft or aperture, near the entrance, admits the water of the sea from some distant communication, when the other parts of the caves are dry, shewing a connexion with those deeper passages, which are never abandoned by the tide.

The strata present, on the north cliff, the same dip (the amount of inclination being rather increased) as on the southern side, and consequently the passages, wrought by the action of stones and waves, terminate oftentimes at the level of a bed or stratum, which at the entrance formed the roof; and the whole cliff differing little except in the existence of their fissile anthracitous seams, in compactness and texture: the geognostic relations, or the circumstances of the disposition and the form of the caves, are more influenced by position than by a resistance which is pretty similar in all parts, and these relations less interesting than when a great variety of mineralogical constitution prevails, are yet important from the instructive examples which they afford of the form assumed by maritime caves, the nature and structure of whose roof and walls is uniform. In all cases the former is more or less pointed, the sides in their upper portion preserving their angularity and fracturing off in oblong square or rhomboidal shapes, and preserving

throughout symetry of arrangement. It may be remarked here that semicircular and segmental arches, or such as have their center in the same line as the spring, (if the expression may be allowed,) or lower than the spring, are not met with in the ampelite formation, though they occur in the limestone and quartzose rocks. The arches of the former are universally pointed or lancet shaped, and have their center above the spring, and are described as well about acute or obtuse as equilateral triangles. Towards the lower part of the walls, the rocks become more rounded or water-worn, but are, in most cases, protected by an abundant vegetation or animalization.

The organic creations, which are met with tenanting the rude compartments and recesses of these dark caverns, are distributed in a more or less regular succession, forming zones, which were determined chiefly by altitude, but were also influenced by light, and, in particular cases, by the protection afforded of jutting crags or cavities. As far as the author had an opportunity of observing, these zones of organization were a lower one ascending to a height of from $2\frac{1}{2}$ to 3 feet above the line of low water, and characterized by a small red ascidia which propagated itself in juxta position, like an extensive mamillated surface. These acalephae projected water to a distance when dis-

turbed. Interspersed among them were animals of the genera Vermetus and Serpula. Above this line sponges made their appearance in the dry caves, (though in the deep caverns the same genus was observed propagating itself many feet below the line of low water,) and this zone passing into the last, equalled it in thickness, and was succeeded by another distinct zone of large and isolated Ascidia and of Balani from six to eight feet in width, and sometimes containing local beds of Muscles (M. edulis and M. pellucidus). A handsome species of Sabellaria increasing in large rounded tufts, preferred the light, and occupied with the Fucus edulis and certain Actinia, a portion of the lower zone at the entrance. The wandering green Nereis was met with among the Sponges and Balani. The marine Oniscus ascended on the rocks above high water, where it often became the prey of sea birds. Some few patches of Flustra encrusted the middle zones, where the Sertularia abietana extended his growth hardly beyond a few lines. Fish, Shrimps, the common Crangon, the Entomon Idotea, and various Crabs, more especially the hairy Pilumnus, the wrinkled Portunus, with the Pagurus Crab, abounded among the adjacent rocks. In the pools of the Kilkee caves Echinites were very abundant, but not so at Ballybunian. In the interior of the caves the zones gradually diminish in extent.



THE HUNTER'S PATH.

An excavated space, forming part of the bay of Dune, separates the cliffs containing these numerous and labyrinth like caves, and which, on their summit, give support to the ruins of an ancient edifice, from a cliff where the anthracitous bed placed between the two great beds of ampelite attains a very great developement. The only easily practicable descent into the bay is on the side of this cliff, and in the central part, immediately before it curves to the east, an arch 27 feet high and 32 feet wide at its base opens into a nearly circular space which is about 50 paces deep. The cliff which thus, like a wall, surrounds the circular chamber, is called by the peasants,—the Hunters Path,—from a tradition of a rider having successfully taken his horse round the circuit: a fact in the present circumstances extremely improbable, as it is 46 feet high, and in many places not

more than 2 feet wide. A little to the right is a small cave 11 feet high, 28 feet wide, and 60 feet deep. The upper stratum of the cliff is composed entirely of very black anthracitous ampelite in thin laminæ, which are divided by parallel and transverse veins of crystalized alum, the same mineral occurring in moulds, efflorescences, and in loose powder in the more decomposed beds often contaminated by shades of yellow and ochre red.* The lower stratum which is more compact and 18 feet in thickness near the arch, furnishes no alum. In the small cave beyond, copper pyrites abound, accompanied by Arsenical Iron,† and in the cavities above may be observed to be clothed with a brownish tinted crystalline substance, which is another form of the combinations of alum with sulphuric acid, containing also silica and a mineral alkali in addition. In the vicinity of these depôts of crystals there is a nearly horizontal fissure in the rock, filled with pebbles and clayey detritus several feet above the level of high water. The materials resemble those of the detritus on the summit of the cliffs; but there is no local or general formation at an inferior level which bears any resemblance to it.

The cliffs of Dune bay, belted with the hoar of age, and fringed with a scanty but cheerful verdure, curve round to

* Appendix. (B.) † Appendix. (C.)

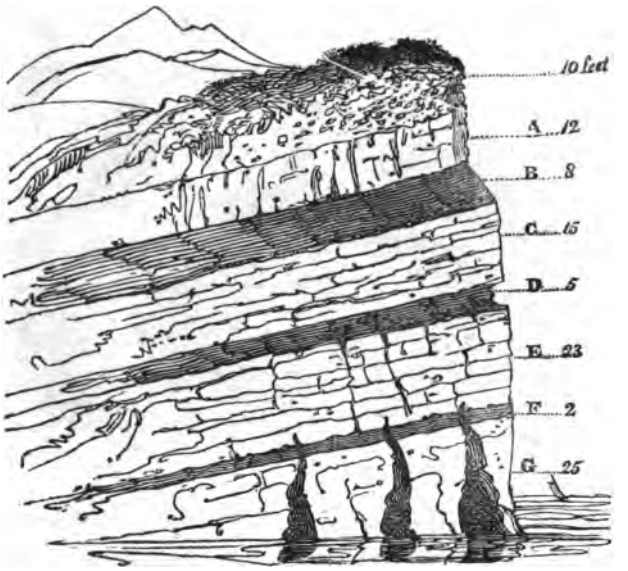
the north, in an hemispherical arrangement, stretching out in a bold headland; on the summit of which, entirely composed of detritus, are the remains of a Danish fort. These cliffs are penetrated by a few caves of inconsiderable magnitude and depth, and do not attain any great elevation. They advance into the sea in a rocky promontory, whose extreme point is the nestling place of a troop of cormorants, and whose base is, in several places, perforated by the waves. At the southern part of this promontory there are some nearly circular cavities in the rock in which the enveloping beds appear curved, and have a metallic lustre like that observed on the surface of meteorites: circumstances which have led some to look upon them as evidences of volcanic action. It is, however, much more probable that they owe their origin to the decomposition or removal of masses of ironstone or ampelite, with disseminated pyrites, disposed in concentric layers like large septaria, and which abound in the adjoining cliffs where similar circular cavities are met with: some only partly emptied of their contents; and which, from the direction of the section, enter the rock in an horizontal manner, while the former, from the waves acting downwards, are left with vertical openings. These cavities or holes are said to have been formerly used by smugglers to secret their goods in; and the bay beyond the promontory, in which they most abound, has, from this circumstance, been called Smuggler's-bay.

Between the promontory and the north cliff of the cave headland, is an immense pile of rock tenanted by numerous gulls, which is perforated by a lofty arch easily passed through in a boat; and again, between it and the point of the promontory a mass of rock is quarried out with statuary boldness into an almost regular sided figure through which the waters have also wrought a passage, while the back ground is ornamented by a singular cone whose uneven sides and isolated aspect give to it a most grotesque appearance.

Beyond this, and a little in the back ground, the strata may be observed to have been divided in such a manner as to form an incomplete arch of so great a regularity that

were the opposite sides to close down, it might be anticipated that the opposed angles or the salient, and re-entering portions would fit one another.

The perforated island cliff exceeds in elevation the cliff of the caves, (114 feet), and is composed, the lower portion (G) of a compact slaty ampelite, then a thin seam, fissile and anthracitous (F); a less slaty bed fissured throughout (E); another bed of anthracitous ampelite, much broken on the ledge and forming the roof of the arch (D); and above C, B, A, three more beds of slaty ampelite, one of which is much fissured in a vertical direction; and on the summit is a bed of detritus, more or less covered with vegetation, shewing that this rocky island has been separated



from the mainland at least at a period posterior to the occurrence of the last geological catastrophe which took place in these districts.* A section of the cone presents us with a summit of thin laminar anthracitous alum slate: a bed of slaty compact rock, and a bed covered with broken shale: a thin laminar and very anthracitous bed corres-

* The accompanying section of the corresponding and opposite cliff to the north of the headland of the small caves, will further assist in showing, by comparison, the close similarity of strata that exists in the two cliffs which were, probably, once continuous. The letters answer to the corresponding cliff in both drawings, and present the same succession of rocks, and same depth of beds.

ponding with the same bed in the cliff of the hunter's path on the opposite side of the bay, and a base of more compact rock, with efflorescences of alum which abound in these anthracitous beds, emitting from the quantity of decomposing pyrites a strong sulphureous odour, more especially when heated by the sun. Cellular iron ore, resulting from the action of fire, was also met with in the interstices of the rock.* It is a curious fact that the summits of

* This cone was on fire about fourteen years before the publication of the History of Kerry, (1752,) in which the circumstance is alluded to at length, with very mistaken mineralogical notions. This is not an uncommon occurrence in these formations. Thus Dr. Richardson, in the Appendix to one of the overland expeditions to the arctic seas, says, "At Point Trail we were attracted by the variegated colours of the cliff, and on landing found that they proceeded from clay baked by the heat of a bed of bituminous-alum-shale which had been on fire; and a few miles to the south-east of Wilmot Horton River, the shaly strata were on fire and giving out smoke." Such also are the examples afforded us by the cliffs of Dutivielle in Prussia, of Aubin in the Aveyron, and of Charmouth in Dorsetshire. The affinity which decomposing pyrites has for oxygen, producing fire in the coal refuse in the north of England, &c., is well known; and the same mineral may be enabled to exert this affinity upon the acids which are contained in the aluminous waters constantly percolating through these rocks, even without the aid of external air, allowing the capillary sulphate to effervesce liberating sulphur, and giving birth to new compounds with bases of carbon and alumina, in the formation of which an intense heat is evolved; and where the circumstances of sufficiency of carburetted products and exposure to air are favourable, to a fire of greater or less extent. The slow decomposition of the pyrites, which act as so many little galvanic piles, according to De Humboldt, (Personal Narrative, Vol. VI. p. 106,) is the cause that renders the waters alumiferous, the contact of so many humected heterogeneous substances as potash, sulphuret of iron, peroxide of iron

all similar cones were found to be formed of the same fissile anthracitous beds, shewing that the mode of disintegration of those beds tended to produce that peculiarity of form; while on the contrary a more or less squared top belonged to the pillars in which the harder and more compact beds formed the summit. To illustrate this fact a sketch has been added of a cone which occurs in a bay to the south-west of Baltard Point, in the county of Clare, and which was kindly taken for the author by his friend Lieutenant Weller, R. A.—(*Vid. Frontispiece.*)

The laminar and slaty rocks, belonging to the great formation of transition clay slates and ampelites, previously dipping at a small angle to the west, rise beyond the promontory of Dune Bay, to the north, increasing in the amount of their dip till they are seen reposing upon the flanks of the limestone rocks of the next headland, which, from a peculiarity in the disposition of the alternating beds, visible at a considerable distance, and pourtrayed in a former sketch, may be called curved headland.

carbon, etc., necessarily leading them to a change of state and composition. But there are, more especially in the cliff of the Hunter's Path, crystals of alum which do not originate from such decomposition though the same torrefaction may be necessary for their elaborization, as is carried to an extreme, or to the ignition of the materials, in the production of the present phenomena. Query—Were the cliffs on the coast of the county of Clare ever on fire? and did the same circumstances of igneous combustion give origin to the cones of Baltard Point and of Dune Bay?

In the center of the headland, the strata are nearly horizontal; they then gradually dip to the south, curling round, and finally assuming an inclination equal to that of the ampelites which they support, and which form a picturesque ridge of nearly perpendicular rocks between this and the promontory of Dune Bay. On the same side of Curved Headland, a fissure of only a few feet in extent gradually widens into an inlet, about twenty feet wide and fifty deep, and a passage much blocked up by rocky masses that have fallen from the roof, leads in a cross direction to another fissure not more than three feet in width, opening along nearly the whole length of the inclined stratum. A fissure of greater extent occurs again beyond, through which the waters have wrought their way to some depth, and a cave may be observed immediately above high water mark, at the point of the headland. The strata to the north become more horizontal and exhibit a fine example of stratification in an inlet which enters from that direction, and is bounded by perpendicular walls terminating in a deep but not lofty cave. The height of the cliffs here is 111 feet; and while the westerly cliff advances only 150 feet from the entrance of the cave, the easterly cliffs project 374. The strata in the former descend in a stair-like succession, and have divided themselves into horizontal masses which sometimes remain isolated like columns on the face of the precipice. The rock is chiefly a compact,

sonorous, and argillaceous limestone; its strata are very distinct, and the beds mostly from one to two feet in thickness. At the lower part of the cliff they are divided by thin seams of more argillaceous rock, and beds of black alum slate occur above the divisions of the first great mass, and in two separate seams near the upper part. The stratification is very regular in the lower part, but becomes curved and irregular near the surface.

Beyond the inlet and caves of Curved Headland, the cliffs recede to the east, preserving their direction for a short distance, and then suddenly the external beds curve round, and dip at an angle of 50° to the north, and continue to preserve the same dip and direction to the bottom of the bay, where they support a number of elevated and contorted strata of alum slates, which repose on both sides on the opposed cliffs—in both cases limestone—and thus present in the center an horizontal disposition, which is the line of junction of oppositely inclined beds.

The colours of these alum slates, contaminated by decomposition and the mixture of adventitious ingredients, are most various; and from their great beauty and the striking character which they impose upon this bay may well give to it the name of Colour Bay. The beds in more immediate contact with the limestone,—which is here

of a bluish white colour, and contains large veins of calcareous spar with small specimens of fluate of lime,—are the anthracitous beds, in this case extremely dark, and dividing into small rhombs, with Aluminite and Katherite in the interstices, and they are succeeded by a number of thin strata, of white, red, ochre brown, gamboge yellow, and bright yellow, with black stripes, to the opposite end of the bay, where they are succeeded by beds of limestone, which project beyond the entrance—a distance of more than three hundred yards—in low cliffs, which are separated from the mainland by a very narrow bay. The same features of a change of dip and direction from the nearly horizontal to highly inclined, occur at the next headland, which from a small quantity of organic remains, belonging to the genera Euomphalus, and a transversely striated bivalve, observed there, the Author—for the purpose of distinction—has called Fossil Point. The variety in coloration which shews itself in the bay last described, appears to originate in the presence or absence of mineral ingredients, which exist but in minute proportions in the rock itself, and are consequently liable to much uncertainty in their predominance. Thus the common source of black in the ampelites, is the presence of carbon, and the same rock may be white from its absence, though mostly in such cases accompanied by a clayey decomposition which gives them a buff or cream colour; brown and reddish brown or ochre brown, are tints

caused by the peroxides and hydrates of the peroxide of iron; yellow by the decomposition of the salts of alum and the liberation of sulphur; yellow tinged with iron gives a bright red and crimson colour, and yellow with an admixture of bluish-black gives a green tint, both of which are communicated to whole beds. The coloration, indeed, of the whole of these cliffs, independently of those of this bay, is much varied; the causes are, however, mostly more superficial than in the present case—the white colour of the cliffs often originates in the growth of pulverulent lichens, from the presence of the agaric mineral, and still more local causes, and the abundance of matters percolating from the more fissile strata, loaded with salts of iron, and in some cases of copper, incase the rock over which they flow in streams or percolate in drops, with bands of red and brown. When there is copper in combination with sulphuric acid, the tints are bright blue, and when iron, green; but tints or shades of yellow are more common from the contamination of moulds and flakes of alum, and from the partial and clayey decomposition of the more slaty rocks. These bright tints having always the same sombre ground of cliffs,—dark and brown from long exposure, or jet black in the fresh changes wrought upon them by constantly active agents,—afford the most beautiful contrasts; and though every bay and every cliff has not the long well-described lines of pink and green and

yellow, which are to be seen in Colour Bay, still in other situations the effect of light and shade are exhibited to much greater advantage, when opposed to the depths of colouring which is spread on their surface and in their cavities, and which rivet the attention at every turn.

A form of cave is met with to the north of Fossil Point, which is afterwards so frequently repeated in the continuation of these cliffs, and in Copper-mine Bay, so called from the abundant veins of copper pyrites which were met with in one part of it, as to give, more especially when seen from the sea, one of the most striking features to this part of the coast. The formation here alluded to is of triangular caverns from the fracturing off of portions of the strata. The limestone of Fossil Point presents the same disposition of rocks at its northern side as it does on the southern, and as Curved Headland also does on both sides; the strata which are horizontal at the extreme point soon afterwards curve away at a considerable dip into the bay, supporting at their further extremity slaty rocks which are elevated on their sides. The former, first undermined to a certain extent by the waters, have at different heights above the level of high water, fractured off at right angles or vertically to their dip, leaving one entire stratum, supporting those above, to form the roof, which inclines into the sea, the opposed side being formed by a ridge of

fractured strata, and the sea forming the base of the triangle; and these caverns from the great exactitude of their figure and the order in which they mostly succeed one another, at the extremity of each succeeding cliff, so as to form in perspective a row of gradually diminishing triangular caves, lead them to rank among the most interesting of the various excavations of this cave fraught shore.

One of these regular-sided caverns, whose entrance is near the extremity of the cliff of Fossil Point; is seen opening into an uncovered space, probably formerly a great fissure or cleft in the rock, by one of which it is preceded at but a short distance, and it may then be observed entering again in a straight line on the opposite side. It would be difficult to say, in a case like this, whether the cave has been formed by the action of the waters continued through the first inlet, into that on the opposite side; not being many yards wide; or whether the fissure has been enlarged since the formation of the cave.

A bay occurs immmediately beyond Fossil Point, which exhibits, upon a small scale, the same features as the larger bay of Dune, and Copper-mine and Colour bays; that is to say, shelving rocks of limestone, supporting thin beds of a disintegrating material at their extremity, the oppo-

site side being again formed of the same mountain rock. Indeed the situation of these advancing headlands and promontories,—formed of compact and hard limestone,—the curves of the rock commencing immediately beyond the point, shewing that the same circumstances existed with regard to the entrance as obtain at the extremity of the bay—the elevation of the beds on both sides of the opposite headlands, and the great liabilty to decomposition and disintegration which characterizes these latter formations, afford very strong grounds for presuming that the greater part of these bays, and probably the whole of Colour Bay, have originated in the long continued operation of causes now in existence.

The cliffs which extend along the base of Copper-mine Bay, abound in natural curiosities, which deserve at least as much care in their description, as is consistent with brevity. They extend from a few cottages, which are situated at the southern extremity of the bay, to an inlet which enters to receive a stream of water, and above which a pole has been placed to give assistance to shipwrecked mariners, occupying altogether a space of 360 yards, and being above a hundred feet in perpendicular height. The shore is partly pebbley, and partly rock, and is crossed by two long ridges of harder material than the other strata, while the disposition of these is in two opposed curves, the

beds rising to the north and south, at the extremities; and curving round to meet one another in the center, thus the amount of dip or angle of inclination is greater at the extremes, and the amount of curvature is greater at the base of the center of the cliff, than towards its upper part. Indeed at the entrance, strata of limestone and white siliceous shist supporting ampelites, are nearly perpendicular, while beds in the upper part of the cliff, in the medial line approach as nearly to the horizontal.

A great rock of alum-slate towering up almost perpendicularly—divided into polygonal figures of the greatest regularity—the smaller parts again divided in their assemblage into the same form, more or less accurately determined, and uninterrupted by the interposition of any other beds, are the great and striking features of the southern extremity of this bay. The peculiarity which belongs to many rocks, of assuming more or less regular forms, is well known; it is exemplified in basalts, (Causeway); in melaphyres, (Fairhead); in porphyry, (Caucasus); in sandstone, (Dunbar); and in many other rock formations; but we must distinguish between the original tendency of mountain rocks, to assume a definite form in connexion with their mode of origin from such as originate in actions which have taken place posteriourly, and which may have been capable of impressing a new character upon the rock—from crystallization on the one hand,

and from modes of disintegration on the other. Constancy of form in crystallization, belongs to the smallest parts which can be obtained by mechanical division, and is consequently supposed to communicate itself to the integrant molecules of a body: though the figures produced by the combination of their parts, may vary with the period at which the process of crystallization has stopped, the rapidity with which it has taken place, the addition of adventitious substances and other causes; yet the simple forms into which the compound figures may be made to resolve themselves are considered as the primary or elementary form; while the modifications which these may undergo—mathematically expressed by the relation of their planes and angles,—their bevelling and accumination;—and physically by the altered laws of combination, influenced by time and proportion, (isomorphism), are in modern crystallography attached to certain systems of forms, through which the same mineral bodies appear to revolve, embracing all the modifications of the same system, but supposed never to pass its extremes. Crystalline minerals are consequently better characterized, as in the natural system of plants, by similarity in the amount of angles in the one case, as by a greater number of analogies in the organic structures in the other, than by the mere capability of being, in many cases, reducible by practice or theory to a geometrical figure of so great a

simplicity as to constitute one of the most elementary forms which any particle of matter, bounded by planes and angles, could be capable of assuming. Regularity of form in mountain rocks, more particularly as observable in Basalts, results from a mode of aggregation which has been supposed, with some degree of probability, to be induced by the effects of lateral pressure on melted or partially liquid spheroids; and in this case the form which is given to the mass does not belong to the separate parts, whose fracture is uneven and irregular. A spathose structure which the author has figured—(Edinburgh Journal of Natural and Geographical Science, vol. II.)—as belonging to masses of gneiss rock, subjected to the action of fire in the walls of the vitrified forts of Scotland, and to beds or clay ironstone in contact with the toadstone of Derbyshire; —which occurs also in coal in contact with a dyke of greenstone in Ayreshire—(Jameson's Mineralogy): and in a slab which formed the floor of a furnace, (Macculoch in Journal of Royal Institution)—and which have been adduced as illustrations of the mode of action by which a similar tendency to prismatic division might have been given to rock formations of a more general character, cannot certainly take their origin in circumstances precisely similar to those which have given a determinate form to the alum slates, as these conditions cannot well be supposed to have been in existence. Yet notwithstanding the first

appearance of organization, at the period of the formation of the latter, there might have been an approach to a similarity of circumstances from their consolidation taking place at a lower temperature than that of the older crystalline rocks, but much higher than that of the succeeding, partly sedimentary and partly crystalline formations. Under any circumstances they tend to show that where there are different modes of aggregation, as in gneiss and sandstone, and different degrees of cohesion, as in coal and ironstone, which latter are homogeneous masses, that similar causes may produce a similarity of effect, entailing changes in the arrangement, not of the molecules themselves, but of the particles which constitute the extreme of cohesion, and give origin to columnar coal and ironstone to columns of sandstone and porphyry and to the prismatic division of gneiss and other rocks. But in the present case there are some peculiarities in the connexion which exists between the form of alum slate and the crystalline form of aluminite which are highly deserving of consideration; for there is nothing at all improbable,—or that verges upon the domain of hypothesis,—in supposing, that if, as the argument has before been placed, there are two extremes of arrangement, applying themselves, one to molecules, the other to particles or molecules of greater size and producing forms which are continuous in the one case, in the minutest divisions we

can effect, or that in the other only exist in the aggregate,—that they may pass by gradual changes from the one to the other, and that thus, the form assumed by a mass may be more or less influenced by the mathematical figure which the laws of nature have impressed upon its ultimate molecules; and further, that, that which belongs to each separate part, may also communicate itself to an assemblage of these parts; or in other words, that a number of rhombs may arrange themselves into a similar figure upon a more gigantic scale, as we see with greater certainty as to the reasoning, in the grouping together of the simple forms of some crystalline substances. In basalts, whose structure is homogeneous to the naked eye, we do not see the regularity of form which has been given to any of its masses in an aggregate, communicate itself to any of its parts; while, on the contrary, in the alum slates of Ballybunian we observe a division into rhombs result from the fracture of the larger masses, with very nearly the same regularity and certainty as would belong to a perfectly crystalline substance.

The circumstances under which, this interesting phenomenon of regularity of form in the separate parts of a whole mountain rock, exhibit themselves here: impress the mind very strongly with the notions supported by analogous cases, of a character communicated to it by the same causes which raised these formations into their present

highly inclined position, acting upon them in a state of partial consolidation resulting from gradual loss of heat; but this opinion is advanced with extreme caution and deference to the dubious nature of such investigations.

Regularity of form, induced by peculiarities in the mode of disintegration is, as has previously been observed, common to many rock formations, and more especially to granite, gneiss, certain lime-stones, sand-stones, and some shistose rocks. It is probable even that the cubical masses, in which we find the thick beds of gypsum at Montmartre, dividing themselves, are rather the result of fractures occurring since the consolidation of those beds, than connected with the mode of formation of that rock: and the same thing may be said of the vertical fissures in rock salt.

It is quite evident, as a further observation, that the amount of this regularity, and the undeviating manner in which it will affect the whole character of the rock,—giving a similarity of form to all its naked sections, cliffs and precipices, and stamping the peculiar features of its scenery,—will depend upon the degree of accuracy with which the same cleavages communicate themselves to the minutest portions of the mineral mass, and the constancy with which the same forms are every where repeated under similar circumstances.

These are the lessons which nature gives on the relations of proportion and continuity, taking their origin in the harmony of form, size, and figure, and which are exhibited here in a manner that impresses us with the same ideas of taste, beauty, and excellence, as the most successful and effective architectural designs which genius has ever wrought from new combinations of laws, themselves first obtained from the study and observation of nature. De Humboldt has remarked (Researches concerning the Institutions and Monuments of the Ancient Inhabitants of America, vol. 1, page 40,) that the influence of picturesque views of mountainous countries on the rude monuments of indigenous tribes become the more perceptible the farther man is removed from civilization,—"what a contrast," says this philosophical traveller, "between the architecture of a tribe that has dwelt in vast and gloomy caverns, and that of hordes whose bold monuments recal in the shafts of their columns the towering trunks of the palm trees of the desert!"—An accurate knowledge of the origin of the arts, it has been truly said, can be acquired only from studying the nature of the site whence they sprung, and it is impossible not to foresee that a further investigation of the connexion of objects whose relations have thus been established by those who applied themselves most philosophically to the study of the human mind; will rapidly tend to the improvement of styles made up from the combina-

tion of systems—originating in opposite circumstances—and presenting incongruities and anomalies in figure, and arrangement, which could only result from nature first perverted, those pervertions grouped together and accumulated with mistaken ingenuity, and the whole transplanted to climates and countries with which the elementary architectural forms have mostly no natural relations.

The cliffs of Ballybunian are even less remarkable for their dimensions, than they are for the singular form of rocks which seem as if carved by the hands of man; and independently of the lofty mural precipices,—whose angular proportions present every variety of arrangement, as in Smuggler's Bay, where they oftentimes are semicircularly arranged like the groin work of an arch, or the tablets or small strings running round a window, or are piled above one another in regular succession, presenting a geological phenomenon of great grandeur and magnificence,—they have also other distinct beauties, which originate frequently in nearly similar causes. Few scenes can, indeed, be more striking than the disintegration of the same formations in nearly circular basins, the descent into which, of stair-like regularity, assimilates them to baths imitated from the ancients, or the more extensive arrangement of stratification in steps, which is displayed to great advantage at low water, at the south western extremity of the bay of Kilkee;

yet in point of regularity and interest these phenomena are much surpassed by the rhombic domes in the interior of the caves of Ballybunian, and by the appearances presented in the mode of disintegration of many of the beds which occupy the face of the cliffs. The latter peculiarity, which is observable at the entrance of Copper-mine Bay and other places, but is seen to the greatest advantage on the south of the bay, between it and the Eagle's Nest, consists in an angular disintegration, in which the solid angles jut directly from the cliff, and the two planes separating at the same angle, are succeeded at equal and similar distances to the right and left by other advancing and receding planes, and this continues often without the slightest interruption in their uniformity, for several hundred feet, constituting a fret work of the most perfect description. The amount of the angles is always the same, but the extent to which they are carried, and the spaces which they occupy, is influenced by the depth of the strata, the entering angle being always of greater dimensions when the stratum is deeper. This phenomenon is also repeated in the cliff neighbouring the waterfall, but is not observable in the caves where the cleavages are generally parallel to the direction of the passage, when forming the sides, and entire or rhomboidal, when forming the roof.

Beyond the cliff with rhombic forms, the precipices advance to the west, terminating in a ridge of harder rock, which has resisted the action of the waves, and projects to a short distance into the sea; between this and the second ridge are several caves, the nearest of which is pretty regularly arched, but not lofty, its sides are coated by a stalactitic or incrusting production, which is also met with in other caves; its structure is cellular, its specific gravity small, colour reddish brown, and its form in lines of regularly succeeding waved laminæ; it appears to be an admixture of silica and alum coloured by iron. This cave is remarkable for the quantity of iron and other mineral substances, which are held in solution by the abundant waters which percolate down its sides, they give to it every where a metallic lustre, and various colouring, and the waters are tinged with similar substances; sometimes their murky pools are seen to hold in suspension flakes of insoluble alum, at others the whole mass is black and turbid, and bubbles of noxious gas are constantly rising from their depths, the consequence is, that, except at the entrance, no living animals are found thriving in the waters of this mephitic cave, and even the hardy marine plants do not appear to vegetate there,—the aspect which the dark metallic cast of the rock, the poisonous looking waters, the absence of animal and vegetable life, combined with the unpleasant effluvia, gives to the whole,—is that of desolation and

death, and is repulsive in the extreme; nor will it fail to remind the traveller that realities can sometimes exceed all that poets have attempted to pourtray, or that imagination could conjure up as bad, for accompaniments to the entrance of the refuge of sin.

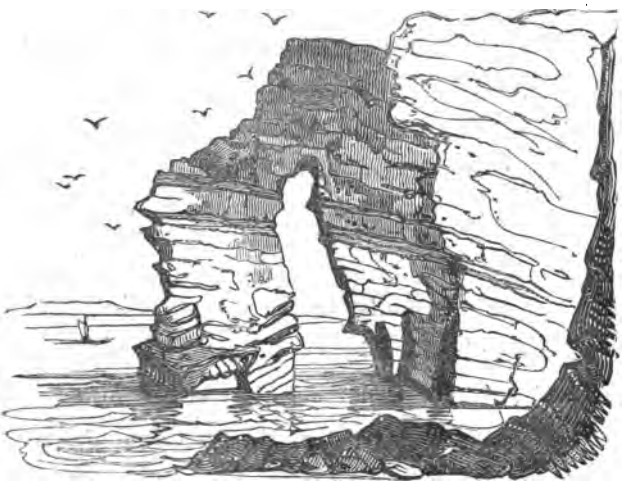
Beyond this is a cave of inconsiderable depth and dimensions, but whose bright bluish green colour, observable from a distance, first led the Author to expect that he would meet with copper, probably in abundance, but the first specimens found were brown nodules of Iron Pyrites, abounding in the cavities of rock and pools of water, which lay before the entrance, and at the foot of the neighbouring cliff; the nodules in-situ occurred, disseminated throughout the beds of alum slate, and these were divided by veins crowded with small crystals of the same mineral, amid which, occurred interspersed, crystals of Copper Ppyrites. These veins preserve the same dip as the mountain rock, in which they are contained, and are seen at one end dipping to the south, when the lowest of the series are lost beneath the shore, while veins placed at a higher level, are continued along the cliff, and traverse the cave before alluded to, where they have been acted upon, and bared by the action of the water. These veins are also soon lost, and cross out again at the distance of 170 paces, from the curve described by the

rocks rising up to the south, and diminish in richness, till they are lost in the rock itself.

In a productive point of view, the importance of veins of Copper Pyrites (mine de cuivre jaune, Chalkopyrite) must depend chiefly upon the richness of the ore, its abundance, and the continuity of the veins, the facilities to work them offered by their geognostic position, and the facilities of reduction; the details of which, in connection with the present mines, will be given in another place.

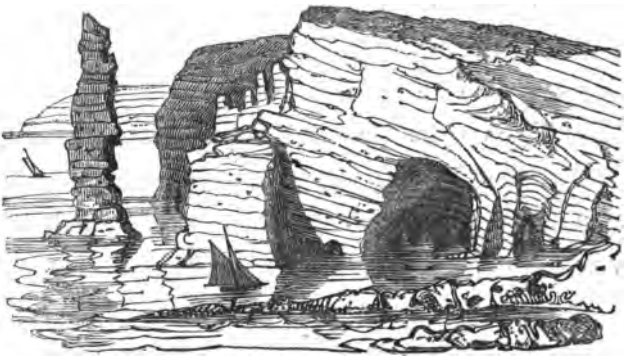
A long ridge, similar to the one described, and like it, originating in the existence of a stratum of harder material, advances beyond the copper caves, into the sea; and immediately on the other side of this ridge, is another low cavern, extending about 180 feet into the rock, and beyond, the cliffs curve round, still preserving their great perpendicularity, and attaining every where an elevation varying from 110 to 130 feet, while they present upon their indented and many-coloured surface, those peculiarities of angular decomposition, which have been described before. At the bottom of the bay, a stream falls over the lofty precipice, which is dry in summer time, but in winter is a considerable sheet of water. Immediately by the side, is the pole, placed there to

render assistance to shipwrecked mariners, and on the right hand, or on the face of the northern cliff, there is a steep and difficult path, which the peasants ascend, even when loaded with baskets full of sea weed.



At a short distance from the extremity of this latter cliff, is the first entrance into the larger caves, and some smaller ones occur between that and the extreme point where the cliff is perforated by an arch, through which a boat can pass with facility, leading immediately into the confined and dark bay, which contains various openings into the same caves. This bay is surrounded by lofty and perpendicular cliffs, which here assume an aspect of fear-

ful magnificence, and is guarded at its entrance by that curious and interesting isolated rock, called the Devil's Castle, or more frequently the Eagle's Nest, whence the bay itself may not improperly be called Eagle Bay. This rock rises up like the tall and tapering shaft of a gigantic column, which has remained alone in the wreck of some great city. In its constitution, it presents an alternation of compact and fissile alum slates, resembling the cliffs of the great caves, and left, as if to show the durability which belonged to apparently so frail a structure.



Beyond Eagle Bay, is another bay of greater dimensions, being 145 yards in width, Eagle Bay being only 30, though it contains, embosomed in its center, some of the wildest and most picturesque entrances to dark and deep caves, that can be well conceived. In ascertaining the

height of the cliffs above this bay, a stone exceeding a pound in weight, was lifted up (the string having caught the wind) as if it had been a feather, and landed upon the green sward.

Near the extremity of the projecting cliff of the north headland of the bay beyond, or Great Cavern Bay, is the first northern entrance into these caves, and consequently the most distant from the southern entrance which is met with on the south side of Eagle Bay, immediately beyond the perforated cliff; and between these two distant points, very few interruptions occur of passages too narrow to admit of navigation in an ordinary sized boat, so as to prevent their being traced in all their various ramifications,—opening as they do in water-worn and lofty arches to the sea,—communicating by long and dark passages, and terminating in stony beaches, far in the interior of the main land;—or, uniting in lofty dome-like and vaulted chambers, from whence again, subterranean corridors and channels radiate in all directions,—offering a formidable labyrinth to persons who might not be acquainted with their arrangement.

The great length of the first or northerly cave, is formed by its continuing along parallel to the face of the cliff which fronts Great Cavern Bay, and into which it opens through the same precipice, by four different apertures;

the third of these is about 15 feet wide, and 20 feet high, and is remarkable for the regularity of stratification, and of cleavage of the rock, forming the roof and sides. In continuing along this cave, from the tortuous course which it follows, the gleam of distant light is soon lost sight of, and the boat enters into a cave of great dimensions, and probably above 60 feet in height. Stalagmitic incrustations abound on its sides, and when the depths are lighted up by a strong torch-light, they shine with a bright metallic lustre. The cave then curves round still more to the north, and terminates some distance off, in a stony ridge. This is the deepest cave which the Author, in company with Captain Sabine, Mr. Pattisson,* and some other gentlemen, explored, and is called by the inhabitants of the coast, the Great Seal Cave; the hunting of these amphibious mammiferæ, was formerly a source of great profit to these persons, and as many as 20 or 30 are stated to have been caught in a day, but they have much diminished in numbers now. The Author only saw one during his stay in this vicinity, though the peasants are tenacious of visits to their haunts, sometimes throwing stones from the cliffs, a circumstance, which in one case

* The opportunity which is here afforded of expressing the gratitude which the Author feels to Mr. D. Pattisson of Kilrush, is most gladly taken advantage of. It was only after many unsuccessful trials, that the deep caves were at length visited, and for final success, it is to this gentleman's attentions that he is entirely indebted.

occurred to his party, when they were obliged to threaten them with their guns before they could continue their researches.

The fourth entrance occurs at the angle formed by the northern cliff, terminating at the precipices constituting the bottom of the Great Cavern Bay; it is wide and arched, and the regularity of form in the disintegration of the rock, very complete. Immediately beyond the entrance, the roof towers up in an imperfect dome, the sides of which are all formed of similar cleavages, the center presenting a succession of rhombic cavities, gradually diminishing in size, until a small space is left in the extreme axis of the dome, as if a rhomb had just fallen out of it. This peculiarity of disintegration, which was before cursorily alluded to, is very common in these caves, and assists in giving to them some of their more striking and novel features.

About ten paces from the fourth entrance, is another passage which has two exits, constituting the fifth and sixth passages. The fifth is remarkable for so great a continuity of width and height as to bring it very close to works of art, and to render its lugubrious low fret work, when entered from the great cave beyond, not unlike the cloisters of a cathedral. The passage to the south,

or the sixth, is more lofty, and passes out before a huge cragg, that advances abruptly into the sea,—is perforated by an arch of inconsiderable height,—and appears to encircle and guard these entrances, forming a bay, with,—at the entrance of the caves,—a fine rhombic dome. Another little cave or aperture opens between the two entrances.

The seventh and eighth entrances pass to the east by a cave about 80 paces in length, and terminate in a beach. To the south there is a narrow fissure about 50 feet from the entrance, and beyond, another passage to the south-east about 40 paces in extent. The ninth passage extends from Great Seal Cave into Eagle Bay, and has two passages to the north, both prettily arched: the second has a lofty entrance and another smaller passage on its western side. The tenth passage is a narrow and zigzag channel leading into Eagle Bay, having three small and very architectural passages not wide enough to admit of a boat; two of which communicate with one another, while another short passage opens into Eagle Bay. The twelfth passage is a great corridor, communicating on the other hand to the north with the ninth passage, and thence continuing to the cave which has several openings into a cave called the Grand Saloon, which last opens upon Copper-mine Bay. These latter passes, thus intersecting one another,

give origin to two cliffs which stand out in the great cave above mentioned, like isolated masses or columns round which boats may turn with facility. The cave itself, from the size of its main entrance, is well lighted, and its lofty rhombic dome, probably more than 80 feet in height, and possessing the most striking symmetry of arrangement, is covered with a thin vegetation of lichens of a sea-green colour, which is again interspersed with black rock and spots or patches of brown and ochre red. It terminates in two channels which narrow gradually; and to the north is another pass which communicates by the twelfth passage with Eagle Bay.

Such, then, is a general outline of the relation of these caves, of which, with a little accuracy of measurement, a good ground-plan might be drawn, and they would certainly present a most curious arrangement and a striking combination of long and continuous subterranean passages.

Caves are to some rather repelling than inviting objects, and it appears difficult to say what expectations lead many to penetrate their dark depths and tread their intricate mazes in defiance of the inconvenience of dirt and wet, and the occasional chance of severer evils. The sentiment may probably be traced to the ambition of exploring unknown

or little frequented places, but still more to that love of the marvellous which man has ever discovered, since he has learnt to admire the works of nature. Recesses in the earth's depths which are tenanted by animal and vegetable forms that shun the glare of light,—galleries and boundless corridors, with alternating contractions and expansions, and vaults and spacious halls that are chiselled in nature's gaudiest mood, all congregate under the head of caverns; and have each separately been looked upon with those feelings of wonder and admiration, which have ever associated their existence with ideas of the passages to abodes of punished spirits or the residence of fantastic or imaginary creations.

Their mode of origin, as well as their ultimate termination, and the points with which they communicate, are oftentimes wrapt up in the same mystery; and they never fail to impress the beholder with a sense of sublimity which is beauty combined with the fearful and the terrific. The situation, however, as well as the circumstances either of the combination of natural phenomena or the association of imaginary terrors, influence the mind in forming these first and constant impressions;—the bounding and impetuous course of a river through its rocky subterraneous passage is as fearful as the stillness of a lake which, dark as Erebus, unfurls its flag of ink in the innermost recesses of

lone caverns, which appear unfathomable in depth or extend beyond the reach of vision;—and not less beautiful is the cave which seems to girt the ocean in its circumscribed embrace, and control the fury of the waves in its own small sphere,—when the waters ascend its firm vaulted sides, breaking with a deafening noise into foam whiter than driven snow, and bounding like a captive beast in vain and impatient fury,—while the distant entrance, with its gleam of bright day, appears like some fixed star whose beam has for ages shed its changeless light upon this scene of elementary commotion and strife.

How opposed to these circumstances are the few moments of calm and quiet which may be obtained in these temples of Janus—with doors ever open—when the spirit of peace comes like a dream over the scene, and hanging its transparent veil to the rocky fretwork, seals up the caverns at their base—when the water glides stilly and smoothly along, streaked with veins of gold and silver, or breaks off suddenly into a sheet of blue and lambent liquid, brighter and more various in its intense hues than finest gems—when the snow-white sand is seen at great depths paraded over by light-coloured fish, while the gentle wavelet lifts the long brown fronds of marine plants, which as listlessly fall again to their original position—when a hundred different animals, sponges shell-fish, and tritoniæ,

petillate on the rocky surface, rendering silence yet more formidable; and when the still obscurity of the depths beyond assists, by its contrast with light and life, in filling the observer's bosom with the deepest emotions of awe, wonder, and admiration;—feelings which are soon, in such a striking scene, soothed down to that calmer contemplation, which dwells with so much earnestness on the evidences of fitness and happiness of creatures placed in a sphere of existence apparently so incompatible with all our ideas of enjoyment,—and marking in a situation, where unobserving minds would hardly have expected to find it,—the same proofs of wisdom, and the same inexhaustible love which has rendered the air and the desert,—the mountain and the sea,—the happy abode of its own innumerable tribes.

A long bay, having chiefly a stony beach, is formed beyond the Great Seal Caves, by the cliffs extending in nearly a straight line to the north. The latter begin here to diminish in height, and one or two promontories jutt out into the sea, affording the only means of descent into the bay below. Among these precipices there are several caves, most of which we explored and found to be of inconsiderable depth and little interest, with the exception of the caves by the side of the first promontory, entering the coast in an easterly direction, and which were several hundred paces in depth and presented throughout great

equality of dimensions. In these caves the seals had apparently taken refuge, since frequent visits had disturbed them in their more extensive abodes.

At the northern extremity of this bay a stream of water rushes over a broken cliff in a pleasing cascade, the stream being at times so thin that the winds scatter the waters before they reach the ground, terminating, on a small scale like the Staubach, in a "torrent of dust." Bullock has described something similar as occurring in Mexico, where the waters of many of the falls, coming over lofty cliffs, are lost in the foliage; but in the fall formed by the river Malkan at the foot of the Elburos, no current of water is stated to be perceived, the fall being so extremely high that the water drops in isolated masses one after another.

The height of this waterfall is 78 feet, and the bed over which the water rushes is a stratum of quartz rock three feet thick: the same rock alternating beneath with beds of ampelite.

Cataracts which take their origin in circumstances connected with the physical features of a country, as in the abrupt termination of a transverse into a longitudinal valley, are also given birth to by causes which are purely

geognostic, as in the presence of a rock of a more compact texture or harder materials than the bed of the stream, or the passage of a dyke of basalt, as in the Deers' Leap, in the Nerbudda, or of beds of limestone (Niagara, Chûte de Gavarnie, &c.); and again by slight changes in the structure of the rock itself, as in mica slate becoming chloritic and compact, as in Powerscourt Waterfall, county Wicklow, or the intercalation of quartzose rocks, (Falls of Fyers and Beauly, Inverneshire,) and similar geognostic circumstances; of which many illustrations might be given. In the present case we have the two circumstances combined, of the termination of a stream over a cliff, and the existence of an alternation of hard and compact, with soft and fissile strata; and it is over a bed of the former, —rising gradually from the north—that the waters flow in an almost undivided stream.

A little beyond this, where the cliff advances to the west, another waterfall much less lofty (23 feet 3 inches,) occurs under still more interesting circumstances; the strata which are composed of quartz rock alternating with alum slate, are here nearly vertical, and a large slab of the former material—constituting part of a nearly vertical bed of rock,—stands before the fall like a screen, being supported on both sides by the cliffs; behind this is a fissure extending a short distance laterally; and in the center and at the lowest part of the rock, the stream of water rolls over, falling into a cavity which is formed by the cleft in the rock and the removal of a portion of the stratum which lay between it and the sea. A rocky doorway is thus left opening into a space kept constantly cool and fresh by falling waters, and which is protected above by the rude architecture of overhanging rocks.

At but a short distance from this natural curiosity, on a wild crag or promontory, jutting out into the sea, and separated from the main land by a narrow chasm, stands Lick Castle,—not less interesting from the singularity of its situation—than it is from the mystery of circumstances, which must have led to the choice of so wild a position. The ruins of this ancient castle do not occupy a space of more than 115 feet in length, and 40 in width, the whole cliff being only, from the first chasm to the extreme point, which is tenanted by cormorants, 365 feet long. The

walls, reposing on a highly inclined plain, are supported by masses of rock, cut into the form of wedges, to fit into a groove chiseled out of the rock itself, while on the other side they rise immediately above the perpendicular precipice, which has remained unchanged probably for centuries.

The portion of the promontory which sustains these ancient ruins, is separated from that which advances farther out to sea by another chasm, which is not so wide or so deep as the former, and not open to day, throughout its whole extent, being crossed by a strip of rock which forms a natural bridge. A bridge of this kind must not be compared to the calcareous arches of Clermont Ferrand in Auvergne, of Cettina (Fortis' Dalmatia), nor to the bridge of Veja, (Des. del ponti di Veja di Z. Betti. Verona, in 4to.) nor to the pierced rocks of the Hunter's Path in Dune bay, or of Alentejo in Portugal, but are rather like the bridges of the valley of Icononzo, described by De Humboldt, where a compact and quartzose stratum has resisted the shock which rent the mountains, when the crevice was formed, and the continuity of this stratum serves as a bridge to cross from one side to the other. In the present case the two chasms are continued in their prolongation across a ridge of rock, which is now separated by the sea, from the promontory supporting the ruins of Lick castle.

A still better example of this geological phenomenon, is offered to us in the neighbourhood of Kilkee, and of which a sketch is given above, where, as in the present case, the strata consist of alternating beds of clay slate, and ampelite, and of extremely compact and quartzose rock, with no cement and scarcely any fissures of stratification. The chasm, in this case, is formed by the falling in of the strata, either from the formation of caverns or the general undermining of the coast, the fissure being about 500 paces in length, and the strata all dipping from it directly into the sea; while the direction of the dip in that part of the coast is parallel to it, or a little to the south, and it is only at the southern extremity that the continuity of the beds is not broken.

In the case of the upper bridge of Icononzo, both strata are quartzose, varying in their nature and compactness. In the lower bridge in the same locality, three enormous masses of rock,—as happened at the Coliseum at Rome, where, in a half ruinous wall, several stones were stopped in their descent,—have fallen so as to support each other. That in the middle, forms the key of the arch, an accident which De Humboldt, who doubts that in any part of the globe a phenomenon so extraordinary has been discovered, thinks might have given the natives the idea of arches in masonry, unknown to the people of the new world as well as to the ancient inhabitants of Europe.

It was Captain Sabine's opinion, and in this the author coincided with him, that the castles of Lick, Dune, and Ballybunian, had been erected by those bold and enterprising adventurers from the north, who went by the name of Sea Kings,—the sea being, indeed, an element on which they appear to have taken up their abode. The numerous tribes of northern nations, who poured upon this country in distant times, had their chieftains, who, attached to no superior, and recognising fealty to no sovereign; took advantage of the diversion in their favour, effected by the invasion of their brethren in arms on other parts of the coast: to effect a landing and to plunder different portions of the land. They appear to have had few establishments and those only on the sea shores, for the immediate purposes of safety, or to secret and defend their plunder until it could be removed in ships. The architecture of these castles or strong holds, is much bolder and is different from that used by the chieftains of the interior, and shows an acquaintance with a style of building much more calculated to resist time and weather, and more suitable as a defence, than the square bawns of Ireland's ancient feudal forts; besides that the chieftains of the latter, could have had no interest in thus secluding themselves from the world, and erecting forts on these wild and inhospitable spots, the only original intention of which could be the defence of their property, and the preservation of their own independance.

The hardy Scandinavians who more probably contributed to their building, made their incursions, or laid the scene of their exploits, in some of the richest agricultural countries in Ireland; as attested by tradition, by the remains of monastic grandeur, and by the name which these districts occupy in ancient Irish history, and retired with their booty to wild spots, difficultly approachable; and where for better security, they erected fortresses: in which they could shut themselves up, and bid defiance to the then elementary art of warfare. In Lick Castle there were recesses for boats, there was even a supply of fresh water, and the rude invaders were in security living in the bosom of rock and wave. It is evident however, that this castle was inhabited long posterior to the time of its first builders, and we find a tale of romantic interest in the history of Limerick, concerning Carrigaholt Castle, which is on the opposite coast of Clare, and in which this fort of the sea king's is not improbably the one alluded to as the residence of the chieftain of that Castle, during the visit of the young O'Brian to Carrigaholt. According to Smith, this castle also once belonged to the Fitzgeralds, a branch of the Desmond family.

It appears then from these descriptions, that the great features imposed upon the coast, and the character given to it by structure and position, are lofty and regularly stratified cliffs of limestone and shales, forming narrow headlands in which the rocks, horizontal in the center, suddenly lose that horizontallity at the sides, and incline to opposite points of the compass, forming plane surfaces, or curving gently round in distinct strata, or fracturing off in angular cavities. The headlands are those of Ballybunian, of the small caves, of Danish fort, of Curved strata, of Fossil Point, of Eagle Nest, and of Lick Castle.

The next great features, are the deep and circular or elliptical bays, always composed of ampelites, more or less horizontal in their stratification, at their center, and vertical or in a highly inclined position at the sides; often waved in their structure; coloured with many various and bright

hues, and wrought by the action of the waters, into irregular and fantastic forms. The bays are those of Ballybunian, Dune, Smugglers' Bay, Coloured Bay, Coppermine Bay, Eagle Bay, and Great Seal-cave Bay. And lastly, the striking character given by the changeless regularity and symmetry of arrangement of the great alum slate formation, which, with its interspersed anthracitous beds at one extremity, and compact strata of quartz, at the other, form cliffs which present us with a natural scenery as various and striking as is probably to be met with on the coast of Europe, whether in the arches by which they are perforated, the isolated points or cones into which they decompose or are burnt, the caverns by which they are crowded, or their division and separation into great polygonal masses, each distinct portion of which, appears to be a representation of the same circumstances which gave origin to the arrangement of its smaller parts, in polyhedral forms—communicating a determinate figure to the whole,—and resembling an architecture of the most minute and elaborate kind, and which can only be compared as a natural curiosity, in point of regularity, and other associations, to the columnar basalts of the Giant's Causeway, which they probably equal in interest, and certainly surpass in point of rarity.

The natural curiosities or phenomena, resulting from the above mentioned circumstances of structure and position,

are then; 1st. Cliffs nearly perpendicular, and divided into forms possessing a striking symmetry of arrangement, both in their original configuration, and in that, subsequently entailed upon them by the destructive agency of external causes. 2nd. Isolated masses, forming islets—square shaped, the upper stratum being compact or conical; and pointed, the upper stratum being fissile; or partaking of both characters, and rising up as a single column. 3rd. Arches, through cliffs advancing into the sea, through isolated rocks, and through walls of rock surrounding circular cavities. 4th. Passages wrought out between strata, and opening to day, and passages or inlets formed by the falling in of the roof or platform of rock, mostly above caves. 5th. Circular openings, also occasioned by the falling in of the roof. 6th. Fissures or seams, and empty spaces, occasioned by the parting of the masses, or the vertical dividing of the strata. 7th. Clefts which are vertical and transverse to the direction of the strata, and which are vertical, but parallel to the dip of the strata, as at the small waterfall. 8th. Caves; longitudinal, such as are wrought by the action of the water and stones, and further increased by the fracturing off of the strata above, as in most of the caves of Ballybunian headland; transverse, or wrought almost entirely by the action of stones and waves, and consequently seldom lofty, for when they are at right angles to the dip, they cross the fissures of cleavage. Caves are

also formed by the breaking off of strata, inclined at considerable angles, and giving origin to caverns having three unequal sides, and small caves further originate in the mere existence of hollows or empty spaces, between strata, as at Fossil point, and at the cliffs advancing from the south, from Copper mine bay.

The mountain rock which has been designated as the great alum slate formation, belongs peculiarly to that period in geognostic chronology, which is characterized by the first appearance of organic life. There are strata and argillaceous deposits, which also contain much alum, in rocks of a more modern date, as in the Lias deposits of Whitby, or even the plastic clay of the Isle of Wight, but the formations belonging to a period of transition between the crystalline and sedimentary rocks, present features which are peculiar to the period of the first intercalation of beds, formed by primitive oxidation, or consolidation, with others which have resulted from the aggregation of parts belonging to these formations when broken up, and attesting that changes in the aspect of the earth's surface had begun to take place previous to their formation—evidences which are further supported by the first appearance of animal life, and the distruction which appears to have taken place of an organization, limited in its vital attributes, and in its terrestial distribution. It is

difficult to say what were the circumstances necessary for the first developement of organic life and forms, but there is every reason to believe, that in temperature and in gaseous constitution, and in the meteorological phenomena of the atmosphere, there was a wide difference from things as they at present are.

The alum slate formation, extends with only the interruption of the Shannon, whose bed undoubtedly flows over the same mountain rock, from the cliffs of Baltard point, in the North, to Kerry-head, a distance of nearly thirty English miles, in a direct line, and consequently attaining a developement, which is perhaps unequalled in Europe. The thickness of the formation observed from below-upwards in the mine of Valenciana, was 263 toises, and the same formation at the mountain of Santa Rosa, near Los Joares, where the Indians collect icè in small artificial basins, was, according to De Humboldt, more than 3,000 feet in thickness, and, according to the same author, the quartz rock, on the western acclivity of the Andes, (Contumaza, Namas,) attains the enormous thickness of 6,000 feet.

Transition clay slate, to which the formation of alum slates belong,—and aluminous ampelites are looked upon by Al. Brogniart, (Tableau des Terrains, p. 285.) as modifica-

tions of clay slate, and by De Humboldt, (Superposition of Rocks) as clay slate, surcharged with carbon,—is characterized both by its extreme variableness, that is, by its continual tendency to change its composition and aspect, and by its containing a great number of beds, some of which, by their frequent repetition, appear to form with it, alternating rocks; by the same association and alternation of similar or different members of the series, resulting not so much from internal developement, as from the intercalation of new members of the great transition groups giving to the whole its type of superposition, and constituting the characters of the formation—and lastly, by the constancy and independance of these periodical oscillations of different formations or partial members of the same associations—associations which characterize the transition rocks, much more than the analogy which the succession of rocks of similar mineralogical constitution presents in every group.

Among the first characteristics, we observe that the most usual effects of internal developement are interspersed beds of grey wacke slate, (clay slate), of limestone, of greenstone porphyry, of alum slate, of compact quartz, (quartzite) sometimes with small crystals of feldspar; Lydian stone, and siliceous shist.

The intercalation of anagenites, conglomerates, and transition clay slates of the most modern period (grey wacke slate) cannot be looked upon in the light of interposed beds. These partial terms of the same group, it has been admitted, can either alternate periodically, or envelope, and reduce each other by an unequal increase in bulk, to the state of simple subordinate beds. They must in the first case, assume an independance of formation, which it would be very difficult to distinguish between that which belongs to the different rocks comprising the groups, or terms of the transition series, or to the different and partial members of each group, or association of the same intermediary rocks. Anagenites which are intercalated with the clay slate of County Clare, between Broadford and Killaloe, are absent in the formations of the mouth of the Shannon, and consequently do not require that their age should be discussed now with minuteness. The same remark may be made with respect to limestone, which it is supposed may assume so great a development, as to supersede the other members of the group, and become even insulated, replacing clay slate or anagenites geognostically; and yet, if looked upon as the partial member of a series, attaining an undue extent, could hardly be considered as an independant formation, which it certainly is, in most cases, where the Author has had an opportunity of studying it; but in the present

case, the limestone is only intercalated or interposed, certainly with some peculiarities of aspect and arrangement in the clay slates or ampelites, and this corresponds with what has been mostly observed, for though limestone may become insulated, and lose its accompanying members, it is very rare that clay slate is seen in a space at all considerable, without being accompanied by limestone.

The intercalation of quartz rock, is one of the most interesting features in the geology of this coast. It is most extensively developed at Baltards-point, and off Kilkee, and appears to entirely supersede the clay slate forming great plains between that town and Kilrush, where the country consists of barren moorland and peat bogs, in many places, anciently covered with forests, the trees of which, appear to have attained an enormous size. It is again seen forming high and insulated hills on the opposite shore above Ballylongford, and is intercalated with the ampelites at Lick Castle.

It is not the Author's object to enter at length on the present occasion, upon the important and extensive formations of quartz rock in Ireland, though the possession of a considerable number of interesting observations invites him to the discussion; he must be content with pointing out, that this situation of the quartzites would make a new

epoch in their grouping in the transition series; for among their most striking positions, we see them alternating with white and saccarhoidal limestones, (Dunfanaghy); with mica slates, and clay slates, (Stranorlane, County Donegal; Howth and Bray-head, County Dublin and Wicklow); with clay-slates and ampelites, containing organic remains; (Kilkee, County Clare; Ballybunian, County Kerry); with clay slates and anagenites, (Mount Seephin, County Limerick; Killaloe, County Clare); and with arenaceous rocks, and with beds of culm or anthracitous coal, (Glynn, County Limerick; and County Clare).

The features which belong to this formation,—in its isolation and apparent independance,—when it gives origin to the great mountains of Croagh Patrick, Nephin and Arrigal, and to some of the finest mountain-groups in Ireland; in Killarney, in the Joyce and Erris countries, and in the County of Donegal;—associated as it is with granite and gneiss, (Gagan Mountains, Fintown, Salt-hill, County Donegal); with mica slates and clay slates, (Counties of Donegal, Londonderry, Dublin and Wicklow); with clay slates and conglomerates, belonging to the highest groups of the transition series, (Counties Kerry, Clare and Tipperary); with talcose slates, becoming uniformly red, (red rock of Killarney; Dunlo Gap; plains between Douce Mountain, and the great Sugar-loaf, County Wicklow); placed in an

intermediary position at Ballybunian, and still farther removed from its first associations, in its connexion with old red sandstone (Tralee Mountains,) and by the interposition of beds of culm, and the gradual passage on the one hand, into slaty, and on the other, into aggregated and arenaceous rocks, which have been observed in various localities; and lastly, in the intercalation of these, and other members of the great series, or group of transition rocks,—remains to be told,—and facts are now rapidly accumulating, which will throw much light upon these apparently complex associations.

The intercalation of beds of greenstone porphyry, (Diorites and Melaphyres) does not occur in the present locality, but we find the quartzite associated with these rocks in Killery harbour, County Mayo, on the great road from Glenties bridge to Ballybofey; at the western foot of the Arrigal; and at M'Swine's gun, &c. near Dunfanaghy, County Donnegal; and with similar rocks of a more modern formation, (Dolerites and Basalts) at the summit of the Arrigal, where the Author first observed them in 1832, and at Knockfearny, (Co. Limerick,) where he examined their relations this summer, (1833) in company with Viscount Adare, and Captain Sabine. Lydian stone which abounds in the clay-slate formation of Leadhills, and Wanloch head, with their boulders of diorites, appear to be rare in the same formations in Ireland,

nor was it any where observed in the County of Kerry.* Flinty slate abounds in the great limestone formation, and in the limestones which are intercallated in the ampelites of Ballybunian. Between these and the slates, were also seen beds of siliceous shist in two or three localities; and these substances, De Humboldt has already pointed out, occuring in the formations of clayslate, anagenites, and limestone; and in the form of jasper in porphyry, prove by their presence, the geognostic affinity that exists between these various transition rocks.

In the local and geographical situation of the mountain rocks in the neighbourhood of the embouchure of the Shannon, we observe some leading features which will also assist in pointing out their geognostic associations. From the opportunities which the Author had, at Limerick, of examining collections of fossils from the limestones of these districts, in the possession of Lieutenant Weller, R. A. and Viscount Adare; he is strongly inclined to look upon the limestones in which the daily discovery of crustaceous animals of the genera Trilobites, and Calymene, are effected—independently of the character of the conchiferous fossils; as belonging in part to the transition series. These limestones form in the center of the Counties of Clare,

* The Author also met with boulders of diorites, at the foot of Croagh Patrick, County Mayo, where the quartzite is associated with serpentine and Lydian stone, but could not trace them in sitû.

and Limerick, basins, which in the former have all the evidences of having, till a very late period, been washed by the waters of the sea, or by lakes, and repose upon quartzites, and some of the earliest rocks of the transition series; while in the basin of Limerick, they are interrupted by a considerable formation of secondary igneous rocks, which in the center of a circle, described by the junction of the Caherparry and Caherconlish hills, have elevated the bluish white and fossil beds of limestone upon their sides,—approach the arenaceous quartzites, in the hills near Bruff, and at Pallas Grean,—and advance in their prolongation into the field of anthracitous, and non-fossiliferous limestone at Newcastle, and in the vicinity of Limerick, or bear up fragments of the strata, and preserve embodied in their paste, the organic creations of another formation, as at Carrick o'Gunnell.

These pyroxenic rocks consist chiefly of a rock which is sometimes stratified, having a petrosiliceous basis, mostly coloured by iron, and having frequently irregularly disseminated calcareous spar and chlorite or green earth, (Newcastle; near the County Infirmary, Limerick; Caherparry hill; above the basaltic columns of Pallas Grean, &c.) and which formation containing carbonaceous deposits, has in one case near Pallas Grean, been fruitlessly tried for coal; also of various Breccias, with im-

bedded fragments, and Spilites with crystalline geodes and nodules, sometimes zootic,—of rock having a paste of petrosilex with crystals of feldspar or Porphyry, in columns, (quarry near the village of Caherconlish,) and of basalt in columns and homogeneous (hills of Ballynaguard Linfield, Pallas Grean). The two basalts being however, of totally different mineralogical constitution.

In the igneous rocks of Carrick o'Gunnel, prolonging themselves from the ruins of the ancient and magnificent castle which crown their highest point, in little rounded hills, to the banks of the Shannon; we observe the breccia containing besides fragments of pyroxenic rocks, masses of unchanged limestone, becoming homogeneous in texture, or basaltic, and forming imperfect columns in the front of the precipice of the castle; and then from the great numbers of spheres and geodes of calcareous spar becoming a spilite, and these spherical bodies may almost uniformly be observed to consist of organic structures, more especially Encrinites. The paste of these spilites was sometimes green, sometimes red; the latter probably from decomposition, and calcareous spar occurred in veins and in disseminated groups of crystals, with mesotypes, and stilbites, in isolated crystalline groups, and in nodules, originating probably in the partial fusion of limestone, which in some cases is contained, in unchanged, and imbedded fragments,

and in others being dissolved through the mass, is afterwards reunited by chemical affinity in separate crystallization, as we see on the coast of Fifeshire, in Scotland; shales altered by their proximity to pyroxenic rocks, and converted into spilites, with nodules of calc spar, agates, chlorite, and zeolites. The power which enables the organic remains to resist the same changes, and preserves them so as to allow of their identification, is probably analogous to that which preserves the lithophytic structures in the constantly occurring decomposition of madreporitic and other limestones, and as we observe in some caves of Derbyshire, the more indestructible Encrinites Producti, and Spirifers coating the roof, floor, and walls of the water-worn passages.

To the west, in the County of Clare, the limestones are succeeded by the upper members of the transition series, which cannot be described here in all the variety which they present, more especially in the more central districts of Broadford and Killaloe, and which cross the river at the same points: namely, Foynes Islands on the southern bounds and the west edge of the river Fergus on the northern;—the Shannon narrowing to about one third of its former breadth at the line where this change in geognostic structure takes place. These rocks are argillaceous quartzites more or less arenaceous and

frequently divided into thin beds, and separated by surfaces which are marked by tortuous, serpentine and wreath like convolutions, which, on being fractured, appear highly micaceous. The Author has observed similar appearances in many of the Psamites or sandstones of La Vendée, Alston Moor, Dumfrieshire and in the vicinity of Edinburgh. These arenaceous quartzites, when slaty and fine grained, are much quarried for paving flags, hearth stones, &c. They dip, almost uniformly, to the east beneath the limestones, contain at their upper part the culm measures and in many cases contain impressions of arundinaceous plants, as at Glynn, Kilrush, but more particularly in the plains between Aghadoe and Tralee. They may also be observed passing into more uniform and compact quartzites on the one hand, and into anagenites and conglomerates, on the other.

These quartzites, more or less arenaceous, are succeeded, on the County Clare side, by the other members of the same formation, which are afterwards seen alternating with clay slates, by which they are ultimately replaced. The level country terminates to the south, by the hills beyond Camogue Bay, but it does not become abrupt or alpine in its character, till to the east of Kilkadrane; there a valley filled with a recent peat formation divides the headland with its light-house, from the village of Carrig-a-holt,

while the tower of Doanlicky Castle, on the culminating point above, announces the vicinity of cliffs which front the Atlantic. To the west, the valley terminates in a stony bay, which is supported on the north by the rugged hill of Ray. From this point a series of undulating hills,—rocky headlands—indented but circumscribed bays,—and steep precipices, succeed one another to Loop-head; where a giant mass of rock is separated by a fissure or chasm from the main land, and threatens soon to fall a prey to the turbulence of the ocean. The whole of this district consists of clay slates, ampelites, and quartzites. To the north, beyond Doanlicky Castle, the same formations continue with slight interruptions of bays, in cliffs of varied feature, and wild and beautiful scenery—to beyond Baltard Point, where low ridges of ampelite gradually descend into the plain. These precipices vary much in height, from chronometrical observations on the fall of bodies, made by Captain Sabine and Lieutenant Weller, R. A. the height of the cliffs south of Kilkee, would be about 200 feet, and they exceed this at Baltard Point.

To the south, or on the County Kerry side, the same formations are immediately succeeded by clay slates, whose continuity is only interrupted by the great mass of quartzite which forms the hills above Ballylongford, and is again met with intercalating in the ampelites at, and adjoining

Lick Castle; these formations being again interrupted between Listowel and Kerry-head by a considerable deposit of limestone, which extends beyond that range to the neighbourhood of Tralee, where it reposes on the sandstone hills, which flank, with their interposed limestones, the great clay slate and quartzite formations of the Dingle and Killarney.

. . . . . .

It appears from the observations made on the relation of these facts of geognostic structure with the appearances presented by the coast, and from a comparison of the size of bays and inlets in the clay slate formation, with those of different mineralogical constitution, that the line which is formed of mountain rocks belonging to the first mentioned rocks, have not been denuded to a greater extent by causes which assisted in producing the present outline or configuration of these coasts; that is to say, the last elevation which took place among these formations than the latter, but they appear to be particularly exposed and liable to the degrading influence exerted by causes at present in existence, a tendency which is not diminished by the various power of resistance possessed by the different beds as they concentrate the action upon particular points, and cause subsequent changes to take place upon a large scale from the fracturing off of masses to form islands, the falling down of roofs of caves and the occurrence of long

fissures or clefts caused by the undermining of the cliff below. We find, in the same manner, that rivers running through a sandstone country alternating with shales, wear a deeper bed for themselves than through shales or sandstone alone; for example the Esk at Roslin, near Edinburgh, compared with the Old River at Manchester; for a much more extensive denudation is produced by the falling of cliffs than from the mere mechanical action of pebbles borne along in the stream.

It is probable, at the same time, that this effect tending to produce so much varied and contrasted configuration—give origin to so much beauty and singularity of scenery,—and mark so instructively and strikingly the destructive powers of the ocean, is, at the same time, very confined; and the whole results when appealed to in testimony of the changes of land into sea, and the annihilation of continents for the resuscitation of new territories, are very small; for though there is every evidence that changes are produced, and these changes are, from particular circumstances of alternation of hard and soft material, written with a very legible hand; yet the existence of ancient castles on the border of cliffs, the unchanged aspect of many headlands, the hoary and aged appearance even of cavernous communications, and the general outline of the coast, attest that long periods of time are

requisite for these changes to take place, and that they stand there rather as monuments to attest the power of resistance which the mineral crust of the globe possesses against the destroying energy of the sea, than to chronicle the history of the rapid invasions of an encroaching element.

The geognostic age of the transition clayslates with ampelites, is now well known; and whatever may be the relative ages of the different formations of quartz rock which are met with in Ireland, connected with rocks, perhaps primitive, while others are placed between transition clayslates and limestones, as in the New World between transition porphyries and alpine limestone, and sometimes replacing even the old red sandstone; still in the present case we have every reason to decide upon a distinct formation belonging to the period of transition clayslate with ampelites,—the most modern of the transition series of clayslates,—and another younger formation which is characterized by its containing culm deposits, and by its alternating with, and passing into, arenaceous and breciated rocks, corresponding perhaps, to the primary red sandstone of Macculloch and the Hebridean granular quartz rock of Jameson—an arenaceous texture, as has been theoretically remarked by De la Beche, being quite in accordance with the rocks with which, in the latter case, it is

associated; and being more crystalline when mixed with older rocks, it is again found to harmonize with its other associations; or rather why should we not observe in the mineral kingdom what belongs to the organic world, that the progress and the changes effected in each are gradual, and that from the more pure and perfectly crystalline formations of quartz, to the brecciated rocks of the most gigantic fragments, transitions may be characterized which do not belong to the same formation, but are rather to be sought for in the changes of time and the difference of periods? Though there is no doubt that both modes of investigation would, under favourable circumstances, furnish the same results; and tracts may be pointed out where the successive changes of different geognostic ages are brought by mineralogical variations, within a small amount of deposits.

The nature of the mountain rocks which form the cliffs and headlands, and the relation in which they stand, both to the agency of existing causes and to the varieties in structure, presented by the rock itself; having, to a certain extent, been established;—having followed the changes induced in mineralogical structure by decomposition and disintegration:—and having at the same time attempted to delineate the form and features of those various configurations, in combination with the causes

which gave birth to them: it only remains for the Author to point out how far the ultimate object and end of these changes may go beyond what we can estimate; and how far we are from being able fully to appreciate all that is entailed by these great examples of the workmanship of the Creator, and of His destructive powers "He, who hath gathered the winds in his fists; who hath bound the waters in a garment," has left us much to admire and much to speculate upon—intellectual capability being, after faith, the proudest inheritance of man; but he has also left us much more, which the talons of knowledge can scarcely grapple with, and into the ultimate wisdom and purpose of which, even "star-eyed science" can only peer with an anxious, a wondering, and a soul-wrapped gaze.

APPENDIX. (A.)

Notice of the Birds met with on the Coast of Ballybunian, in the Month of July, 1833. By CAPTAIN SABINE, R. A., A. D. C., F. R. S., F. L. S., ETC.

THE Author has been kindly favoured with the following notice of the birds met with on these coasts, during their short stay there, by his friend Captain Sabine, "Of sea birds, I recognised in flight,—of terns, the hirundo and minuta;—of gulls, the argentatus, fuscus and tridactylus, and I heard of a gull with very red legs, which was, I suppose, the ridibundus;—of guillemots, the troile, Brunnichii, grylle and alba; cormorants, and oyster catchers, abundant; the oyster catchers more frequently in groups than in pairs, although it was the breeding season. Puffins and razorbills. Of land-birds, the only species worth particular remark, is the chough, which breeds in the rocks at Ballybunian, as does the rock pigeon."

APPENDIX. (B.)

Acidiferous Minerals.

It is by no means in the vast formations of clay slates, ampelites, bituminous shists and shales, which occupy so considerable a space among mountain rocks, that saline minerals having a basis of alumina, are most frequently to be met with.

The great natural repositories for these salts, and more especially of the sulphates, are solfatteras, such as those of Vulcano and Stromboli, of Puzzoli and Guadaloupe. They occur also in trachytic formations, and pumice conglomerates, particularly in such parts as appear to have been charried by waters, and which are connected with the tuffaites in which organic remains are met with, as at Tolfa, near Civitta Vecchia (1); Beregezeg and Muzaj, in Hungary, (Beudant) (2); Mont D'Or, in Auvergne, (Cordier) (3); in the Island of Milo, in the Greek Archipelago, (Tournefort); or ready formed in beds covered with sand which are from three to sixteen inches in thickness, at Goubanieh, near Syene, in Egypt, where the caravans go in search of alum (4). Alum is also obtained

(1) Collet Descotils; Memoire sur les Alunieres de la Tolfa; Annales des Mines, T. I. p. 319—374.

(2) Beudant; Voyage en Hongrie, Tom III. p. 446—71.

(3) Annales de Chimie et de Physique, Tom IX. p. 71—88.

(4) Decade Egypt.; Tom III. p. 85.

by the incineration of certain peat formations, and it is known to exist in small quantities, in some springs of Bohemia and Hungary.

Various salts of alum are, however, met with in a greater or less degree of purity in rocks having a clayey basis, and as these salts are obtained from the latter, both by natural and artificial means; their presence assists in diminishing the expense, and facilitating the produce of this mineral, to such an amount, as to render them of the highest importance in a commercial point of view. Such are the sites which ampelites and bituminous shales offer in the most efficient manner, in the repositories of Christiana, (Von Buch) (5); Peninsula of Araya, (De Humboldt) (6); Rio Saldana, (Boussinghault); Ferry Town of Cree, in Galloway, (Jameson) (7); Hartfell Spa, (Dr. Garnet) (8); Birkhill, Dumfrieshire, (Ainsworth) (9); Freisdorf, Moselle, Ramelshoren, (Beudant) (10); at St. George's, Lavencas, and Fontaynes, department of the Aveyron, (Brard) (11); Hurlet, near Paisley, (William Phillips) (12); the upper beds of lias, called alum shale, (J. Phillips) (13); of Whitby, in Yorkshire, and the beds in the plastic clay of the Isle of Wight, (Greenough) (14).

(5) Von Buch; Travels in Norway, by Jameson.
(6) Humboldt; Personal Narative, Vol. VI. Part I. p. 102, et seq.
(7) Jameson; Mineralogy, etc.
(8) Garnet; Tour, etc.
(9) In Edin. Journ. of Nat. and Geo. Science, Vol. II. p. 443.
(10) Traité Elem. de Mineralogie, Tom II. p. 488, et seq.
(11) Brard; Min. appliqué aux Arts, Tom I. p. 309, et seq.
(12) William Phillips; Introduction to Mineralogy.
(13) J. Phillips; Illust. of Geo. of Yorkshire, p. 92.
(14) In Notes to Conybeare and Phillips; Geo. of England and Wales, p. 38.

The various salts of alum which were met with in the clay slates and alum slates of Ballybunian will be best compared with those of other repositories, in their external characters as well as chemical constitution, in the order of their description, leaving as a subsequent consideration, the prospects which they may hold out, of commercial advantages, or of their application to purposes of general utility.

Among the soluble salts of alum were—

1st. Efflorescences of powdery and capillary alum, of a white and yellowish white colour, sometimes sulphur yellow.

2dly. Massive alum in globular concretions, hollow within, or in sparry incrustations of a delicate fibrous texture, of a snow white colour and sparkling lustre, and in veins of from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in thickness, compact, masssive, hemidiaphanous and sparry. All these varieties were acidulous and styptic to the taste, though not adhesive to the tongue. The soluble salts of alum, like some of the insoluble varieties of the same mineral, are made to precipitate their base upon the addition of ammonia, which precipitate, in some cases is dissolved by an excess of alkali. In this case, the liquid, after the alkaline precipitation, gave no residue, but to some of the coloured varieties, the ferro cyanate of potash gave to the solution in water a faint bluish tinge.

The first of these substances was abundant, more especially in Dune and Smugglers' Bays, in the most anthracitous beds; the second and third were not so frequently met with, but were found in a state of great purity in the

interstices of the rhomboidal alum slate, more especially on the south side of Colour and of Copper-mine Bays.

Pretty nearly similar results were obtained from the examination of a much more common mineral, which was found in humid efflorescences of a less chrystalline character, unctuous, chiefly indeed of a buttyraceous consistency, dull and opaque, and meagre to the touch. It abounded most in the decomposing beds of highly carburretted alum-slates, and was only met with in localities where there was free exposure to the external air. Its colour mostly impure white, was sometimes milk-white, at others had various shades of yellow. It had a caustic saline taste, and gave much water by calcination. The aqueous solution was not transparent, and precipitated by the addition of ammonia (alum) and soda (magnesia). Reduced before the blow-pipe with caustic potash, the solution gave a slight precipitate upon the addition of acids.

A fourth species also soluble, occurred in feather-like crystallizations, (alun de plume) which were found accompanying colourless and transparent alum, which ranged in parallel or diverging fibres, mostly in veins. The latter was left as an insoluble residue, which taken up and exposed to the action of the blow-pipe with soda and charcoal, gave a salt, which precipitated by the addition of ammonia, and by that of acids, gave off sulphurretted hydrogen. The liquid remaining after the alkaline precipitation, gave, after evaporation, and subsequent calcination, an alkaline substance, which precipitated by the chlorure of platinum. The ferrocyanate of potash which did not precipitate the aqueous solution, gave a

light blue colour to the salt, from the platina spoon. These minerals occurred in veins from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in thickness, in the most anthracitous beds of ampelites. They were more particularly abundant on the cliff of the Hunter's Path. The flat crystals which radiate in all directions, cross one another like net-work, and thus form layers which are oftentimes continuous for some extent, though the crystals themselves were very small. These layers are sometimes in veins, parallel to the strata of the rock, but were also met with filling vertical fissures. The veins of feather-like crystallizations, also cross one another at different angles.

An examination of the Katherite,* or Katharite, from the mines of Hurlet, near Paisley, made by Mr. R. Phillips, led to a result which gave A $Su.^3 \times 2$ f. $Su.^3 \times 16$ Aq. or a double salt of sulphate of alum, and sulphate of iron; but if the latter exists in any quantity in these minerals, it will be in proportions which will rather come in approximation with the mineral analysed by Berthier, and give only a mixture of sulphate of alum (Katherite) with sulphate of iron, (Melanterie Beud.) and of which admixture we have an analogous example in the mineral brought by Boussinghault from the banks of the Rio Saldana;—with regard to the insoluble substance occurring in veins it is no doubt an impure compound of sulphate of alumina, and sulphate of potash, and must be included as a fibrous variety of Aluminite, in the group of saline minerals, so designated. (*vid. Table.*)

* From καθαρος impermixtus, simplex; in allusion to the absence of potash.

The first and third of these substances, the capillary and stalactitical varieties of Katherite, have been described as abundant in Solfatterras, where they originate from the action of the sulphureous vapours, as the silicates of alumina, which form the chief constituents of the Trachytes, and other matters, amid which these gaseous and mineral repositories occur, (1). But in this case they probably owe their origin to the decomposition of the pyrites, by natural causes,—a decomposition which from its constant tendency to produce similar results, is favoured by art for the production of similar and other forms of the sulphates of alum, in countries where that substance is not obtained in its native form.

Katherite has been found in the ancient works of mines, as Beudant has observed at Schemnitz, in Hungary; and Dr. Henry in the workings of a coal mine, near Oldham, in Lancashire. It is in such cases the produce of actions that are continued in the present day. But the various forms of this mineral substance are more particularly produced by the combustion chiefly spontaneous of bituminous shale, and highly carburretted ampelites. Of this natural phenomenon, examples are furnished to us in the alum works of Aubin in the Aveyron, of Duttweille near Saarbruck in Prussia, in the cliffs of Point Trail, North America, and at Charmouth, in Dorsetshire; and the most abundant efflorescences which are met with at Ballybunian, occur in the burnt cliff.

(1) Gay Lussac Annales de Chimiè. (old series) Tom, 55 p. 266. Humboldt, lib. citat p. 105. Beudant lib. cit. p. 489.

The fourth or feather-like variety of Katherite, *alun de plume* introduced in the appendix to Alunogene, by Beudant, and distinguished as a separate species, by Blondeau and Julia Fontenelle; (1) the author is not aware as having been described as belonging to any other formations than such as are the representatives of the ampelites of Ballybunian, or the deteriorated shists of bituminous shales, and pyritous rocks sometimes belonging to the coal formations, to the plastic clay of the Isle of Wight, or to the lignites of Soissonois, and at Egra, in Bohemia, (2).

It is scarcely necessary to remark, that the different varieties of Katherite would be very precious for the fabrication of alum, could they be obtained in large quantities, for it would only be necessary to dissolve them, and to add sulphate of potash.

The insoluble minerals of alum, for their variety, the perfection and beauty of their forms, and the stability of their external characters, are most deserving of interest of any of the different varieties of the acidiferous minerals, of these rich repositories.

The first of these is the fibrous variety of Aluminite, previously alluded to. To this group, the most accredited of the chemical Mineralogists have given the name of Alunite, suited to the genius of the French language, which says Alun, and hence Alunite, and Alunogéne, but as with us, it is Alum, so we must preserve the name of Aluminite, or Alumnite, and having no appellation for the latter group, have preferred that of Katherite, or Katharite, to a word of foreign structure, and the meaning of which is not distinct.

(1) Manuel de Mineralogie, p. 249.
(2) Klaproth Beitrage, Tom. 1, p. 311.

The second variety of Aluminite which was met with at Ballybunian, is crystalline, and was found coating the cavities of rhomboidal alum slate, and in some places, spread over the walls of the rock, more particularly where there are natural caverns, as in the cliffs between the Hunter's Path, and the sea caves in Dune Bay. This mineral was crystallized in small rhomboids, either simple, or truncated, or obtuse, and variously modified, and grouped one upon the other. The crystals were small and brownish externally. Fused before the blow-pipe, this substance gave off water of calcination, and the solution precipitated in white with ammonia, and blue, by the ferrocyanate of potash.

The next species was crystallized in little hemispherical or globular concretions, composed of radiating fibres, the extremities of which were crystalline. The crystals were translucent, and possessed a silky or vitreous lustre. Its colour was green. There was a white variety which existed in smaller concretions, was opaque, and mostly covered with a brown or red coating. It appeared to be the same substance in a state of decomposition. This mineral was recognized on the spot to be a phosphate of alumina, (Wavellite) and subsequent examination demonstrated the accuracy of this view. It was not attacked by acids at the ordinary temperature of the atmosphere. Fused with caustic potash, the solution in nitric acid reduced to dryness, and taken up by water, gave a gelatinous precipitate with ammonia, a white precipitate upon the addition of nitrate of lead, and a yellow, with the nitrate of silver. The coloured varieties gave a bluish tint with the ferrocyanate of potash.

Wavellite occurred in the ampelites of Ballybunian,

TABULAR VIEW O

A. Sulphates of Alumina.

a. Soluble. Fibrous, styptic.

1. Efflorescences. C
Moffat, (
ex. by R.

2. Mammillated. S
Var. St

3. Scaly. In lamina

4. Massive. Fibrous,
With sulp
1. F
2. B

b. Insoluble. Massive.

1. Reniform. Webst
Conyb. an

2. Earthy. (Hallite.
Auteuil, n
Var. Alu

B. Sulphates of Alumina, and Sulphates of P

a. Soluble. Styptic to the tast

1. Crystalline. Octa
obtained b

2. Fibrous. Always

b. Insoluble. Stony. Alumin

1. Crystalline. Rho

2. Compact. Alumi
(Mohs)
Muraz,
(Klapro

3. Fibrous. In paral
Var. Sili
Old

C. Phosphate of Alumina, Wavellite, Hydra
$A^4 P^5 \times 4$ Aq., (Brogniart).

1. Crystalline. In rig

2. Globular. (*Mam*
Devonshire
In sandsto
Vesuvius,
(Sir C. Gie

3. Stalactitic. Brazil

chiefly in concretions, which were arranged in laminæ, succeeding one another in an oval disposition, and giving rise to nodules, sometimes of more than two feet in length in their longer diameter, and a foot in their lesser, and which were entirely composed of thin shistose rocks, and layers of concretionary Wavellite. At times this disposition was not observable, and the mineral appeared to propagate itself in indefinite directions, between the fissures and the laminæ of the rhomboidal alum slate. The point at which it was found in greatest abundance, is a little beyond the path which leads down the cliff, into Coppermine Bay, and immediately at the commencement of those lofty cliffs, in which the regular form of the rocks and their symmetry of arrangement have been the subject of previous descriptions.

The Author has subjoined an attempt to exhibit in a tabular form, the relation of these different saline minerals, more especially the sulphates of alum, the arrangement of which is very confused in most of our elementary works. He is far from sending forth this table as a complete and elaborate monograph of this interesting group of minerals; the data are not yet sufficient on which to found such a labour. He only hopes that it will make the relation of these different substances more easily understood, and render their various synonymes more especially as applied to their different geognostic positions, as well as their geographical situations of more easy reference.*

* Since writing the above, the Author has received from Captain Sabine, an account of his having revisited this spot, and found veins of silky and plumose alum (Katherite) from half an inch, to an inch and a half in thickness; specimens of which were transmitted, with hemi-diaphanous massive Katherite, which assumes in some places a nearly similar developement. These disco-

Mineralogists were not acquainted before the travels of Mr. De Humboldt, with substances which without addition, calcined or not calcined, could directly yield alum, (sulphate of alumina and potash) except the trachytic, and other modern formations which have been previously alluded to. The varieties of Katherite which have been described as found among the Ampelites of Ballybunian, when looked upon in a commercial point of view, can only be considered as salts, pure in their nature, and not containing potash, while other varieties are mixed with sulphates of ammonia or magnesia. The fibrous varieties of Aluminite, are exceptions to this and the diaphanous and transparent kinds which perhaps abound in sufficient quantities to render their extraction an object of gain, are as pure as the trans-atlantic forms of native alum, of which they are the mineralogical equivalents, though as the geognostic representative of the ampelites of the Araya, in the one case lying on mica slates, in the other, intercalated with sub-arenaceous rocks, there is a difference in position, but apparently hardly any in structural peculiarities, or mineralogical accompaniments.

De Humboldt attached another consideration to the existence of these beds of native alum, in transition slates. "This alum so pure," he says, "and filling beds in the

veries are quite decisive as to the real mineralogical importance of these alumiferous repositories. The author received at the same time, specimens of white porous and opake Aluminite of an earthy texture, styptic to the taste and meagre to the touch, which proved from examination to be siliceous subsulphate of Alumina. He had already separated from masses of Agaric mineral, derived from the same sources, a lighter and more friable substance, which was also styptic to the taste, and compared it with specimens designated in the British Museum by Mr. Koenig as Websterites (Hallite?) that are not radiated or reniform.

clayslate, without leaving the smallest void, can they be of a cotemporary formation with the rock, or must they be admitted to be of a recent, and in some sort, secondary origin; like the muriate of soda found sometimes in small veins where strongly concentrated springs traverse beds of gypsum or clay?" Nothing, says the celebrated traveller, in these places seemed to indicate a mode of formation which may be renewed in our days, the slaty rocks exhibited no cleft, and particularly none was found parallel to the direction of the slates, and consequently these beds of alum must, he considered, be looked upon as being of the same age with the rock in which they are contained. With regard to the effloresced and stalactitical varieties of Katherite which were met with at Ballybunian, there can be little doubt from the circumstances under which they occur, but that they take their origin in actions which are going on at the present day; but with regard to the diaphanous and crystalline variety of aluminite, there may, from its position, and other circumstances, be some doubt, if it is not also a formation, cotemporary with that of the rock, taking the term in the sense attached to it by geognosts, in speaking of beds of quartz in clayslate, or ironstone in bituminous shale.

It must not be thought, that owing to the paucity of the beds of salts of alum, that the rocks of alumslate (Ampelites) are of no importance to commerce. Alum, which is not quarried, ready formed as at Tolfa, is obtained from these latter rocks by the ordinary process of roasting and lixiviation, and such are the means adopted to obtain this substance in most of the mines of Scotland, England, the Netherlands, Sweden, Norway, Austria, and Spain. It is unnecessary in an inquiry of this kind, to detail the

different improvements which have been effected in the manufacture of alum, by the researches of Marggraf, Bergmann, Klaproth, Vauquelin, and by modern Chemists; nor could it be of any interest to add to these hitherto simple mineralogical facts, the discussion of other topics, on which information can so easily and so readily be obtained.

Sulphates of Iron and Copper.

The last of the acidiferous minerals which remain to be noticed, are the sulphate of iron (Melanterie, green vitriol) which occurs in streaks and veins on the surface of the rocks in Copper-mine Bay, mixed with similar incrustations of sulphate of copper, (Cyanose, blue vitriol.) The latter of these substances abounded most, and from giving its characteristic colour to a cave, visible at some distance, has been used to designate a portion of the coast and cliffs in the neighbourhood of Ballybunian.

APPENDIX. (c.)

Metallic Minerals.

The occurrence of Iron Pyrites (Pyrites) and of Copper Pyrites (Chalco-pyrite), in the ampelites of Ballybunian, was mentioned in the description of the scenery of that place. The former of these minerals was found in the greatest abundance in the rocks of Copper-mine Bay, but was also common throughout the generality of the cliffs and rocks belonging to the same formation. The second was only met with as a distinct and disseminated mineral in the same bay, where it also occurred in veins. Cubical* Iron Pyrites was met with crystallized, chiefly in cubes, and in globular, and oval or flattened masses, sometimes mamillated, but not radiated. These masses were very brittle, and had an uneven fracture, with a dull steel-grey surface. Octahedral Copper Pyrites, (Tessular Pyrites, Mohs), occurred in crystals (tetrahedrons) rarely, chiefly as amorphous masses of a globular or botryoidal form. These masses had a granular fracture of a yellow colour, the surface of which, sometimes iridescent, yielded to the knife and did not elicit sparks with steel. Independently of the external characters, which were at once

* According to the system of Professor Whewell; Report of the first and second meetings of the British Association, for the advancement of Science. Report on Mineralogy, p. 361.

sufficient to distinguish between these two substances, a chemical examination was instituted as far as necessary, in the course of which it was found that in many of the globular varieties of iron pyrites, there existed a small amount of copper, but that in general they were very impure, and a very large proportion of sulphur entered into their composition.

These nodules, which were met with in abundance in the little pools of water and cavities of the rock at the foot of the cliffs—occurred in sitû, disseminated throughout the beds of alum-slate, and were divided by veins of a more argillaceous character, crowded with small crystals of iron and copper pyrites. These veins preserved the same dip as the mountain rock in which they were contained, and they are seen at one end dipping to the south, where the lowest of the series are lost beneath the shore, while veins placed at a higher level, are continued along the cliff, and traverse the cave coloured by the sulphates of the same metallic bases, to where they have been acted upon, and bared by the action of the water: these veins are also soon lost, and crop out again at the distance of one hundred and seventy paces, in consequence of the curve described by the rocks rising up to the south, and they then diminish in richness till they are lost in the rock itself. At the northern extremity of this group of veins, the veinstones are yellow and argillaceous, and lay in a very anthracitous fissile slate. Three of these veins cross a cavern, formed at the junction of the slates, with the more fissile beds, and becoming richer in ore, increase finally from two to seven inches in thickness, and cover a bed of ampelite also rich in disseminated nodules. The veins are—1st, a yellow unproductive vein—2nd, a three inch vein, chiefly of small

cubes disseminated in a slaty rock—3rd, a two inch vein soon lost—4th, veins in oval masses, rich in disseminated copper pyrites, losing their continuity of direction, and varying from half an inch to six inches in thickness—6th, a richly disseminated vein, averaging four inches—7th, a vein averaging three inches, becoming poorer—8th and 9th, poor and sterile veins. The distribution of these veins has been already described.

The various analyses which we possess of copper pyrites, furnished to us by Rose, Berthier, R. Phillips, brother to William Phillips, by Furstemberg, Hartwall, and Gueniveau, would give on the part of the first of these, an atomic relation of 2, 1, and 1, between the sulphur, copper and iron, of which this mineral consists; but according to the results obtained by the other analyists, the relations would be 18, 8 and 9 in some, 17, 8 and 9, and 16, 8, 9. These differences, are however, not great, and both Berzelius and Beudant, two of the most celebrated mineralogists of the chemical school, have admitted the formula, Fe. Cu. $Su.^2$ which would oblige us to consider that in the atomic relations which gave 18, 8 and 9, there is a mixture of pyrites, by which we should obtain 8 (Fe. Su. × Cu. Su.) × Fe. Su. With regard to the last of the relations 16, 8 and 9, the formula can only be obtained, as Beudant has done, by admitting an admixture of a substance of the formula 3 Fe. Su. × $Cu.^2$ Su., for these relations give 6 (Fe. Su. × Cu. Su.) × (3 Fe. Su. × $Cu.^2$ Su.) and this is the divergence which it is most difficult to reconcile with the idea which we form to ourselves, from the results of the first analysis; and hence Beudant has admitted a formula which reduced according to present atomic weights, would give $Fe.^2$ $Su.^3$ × $Cu.^2$ Su.

The chemical expression of these different values is not, however, of so much importance, as the fact which is thus established by analysis, of the great importance of the sulphuret of copper, as a metallic ore.

Almost the only minerals which are now employed for the preparation of copper, are the different forms of the sulphuret, and sometimes the carbonate (Malachite). The first species, being the one most frequently met with in that which is most commonly wrought in all the countries of Europe. The latter, occurring only in conjunction with the former, is often reduced at the same time, but it is, perhaps, only in Siberia that it forms the sole object of labour.

The richness of the ore at Ballybunian, the abundance of the veins, and the facilities of working them from their geognostic position and association, do not hold out any sanguine hopes of their ever being turned to very lucrative purposes, at least as repositories of copper; how far the manufacture of the sulphates of iron and copper might more especially, if the alum works were turned to profit, compensate the enterprize of individuals, is a result, for which there are certainly far more promising indications.

Copper pyrites exists in a corresponding situation to that under which it is found at Ballybunian, that is to say, in clayslates and ampelites, of the higher group of the transition series, and under circumstances which render them of national importance, at Ramelsberg, and the other mines of the Hartz, at Herren-Grund near Neusolkin, (Hungary,) and at Zanobar, in Croatia. The mines of copper of Cornwall, Anglesea, and County Wicklow, in

Ireland, are in clayslates, which are more closely connected with primitive rocks, or among the lowest groups of the transition series. It is in these latter situations, that this valuable mineral abounds most, and in which occur the generality of mines of France, the Pyrenees, Moldavia, Silesia, Bohemia, Styria, Tyrol, Norway, Sweden, (Fahlun) and Piedmont. It exists also in the lowest deposits of the secondary period, in similarly valuable repositories—a familiar example of which occurs in the copperslates (Kupperscheifer) of Mansfield.

Mispickel, Arsenical Iron. Immediately to the west of the Hunter's Path,—among the rocks of Dune Bay, and in very anthracitous beds, there occurs a metallic substance of a silver-yellowish-white aspect, in minute and sparkling crystals, and which, before the blow-pipe, fused easily, giving out at the time, a strong arsenical odour. Upon subsequent investigation, this mineral (arsenical iron, Mispickel) not acted upon by dilute sulphuric acid, was attacked by strong nitric acid with energy, emitting abundant vapours of nitrous acid. The solution was coloured slightly green, and precipitated abundantly with the ferrocyante of potash. The addition of alkalies, precipitated red and orange, which precipitates were not dissolved by excess. The addition of sulphuric acid to the solution in nitric acid, did not give any precipitate, nor did the presence of alcohol give any indication of an admixture of silver. The proto-chlorate of tin gave a faint brown precipitate. From the extreme minuteness of the crystals, it was difficult to determine their form with accuracy, but they appeared all to belong to right rhombic, or rectangular prisms.

These crystals existed isolated, or disseminated through the rocks, and also in veins. In the latter case, the metallic substance was accompanied frequently by the same mineral, in a massive form, but in small quantities, and spread in thin silvery laminæ over the surface of the rock. Thin veins of acicular crystals, of a silken lustre, were also found in these localities. They appeared to be a capillary variety of Mispickel, or a collection of straight filaments, composed of very thin and elegant crystals. Their structure was best seen by suspension in water after a partial friction of soda, or any soluble substance that would effect a mechanical division of the particles, and afterwards leave them in suspension in water.

FINIS.